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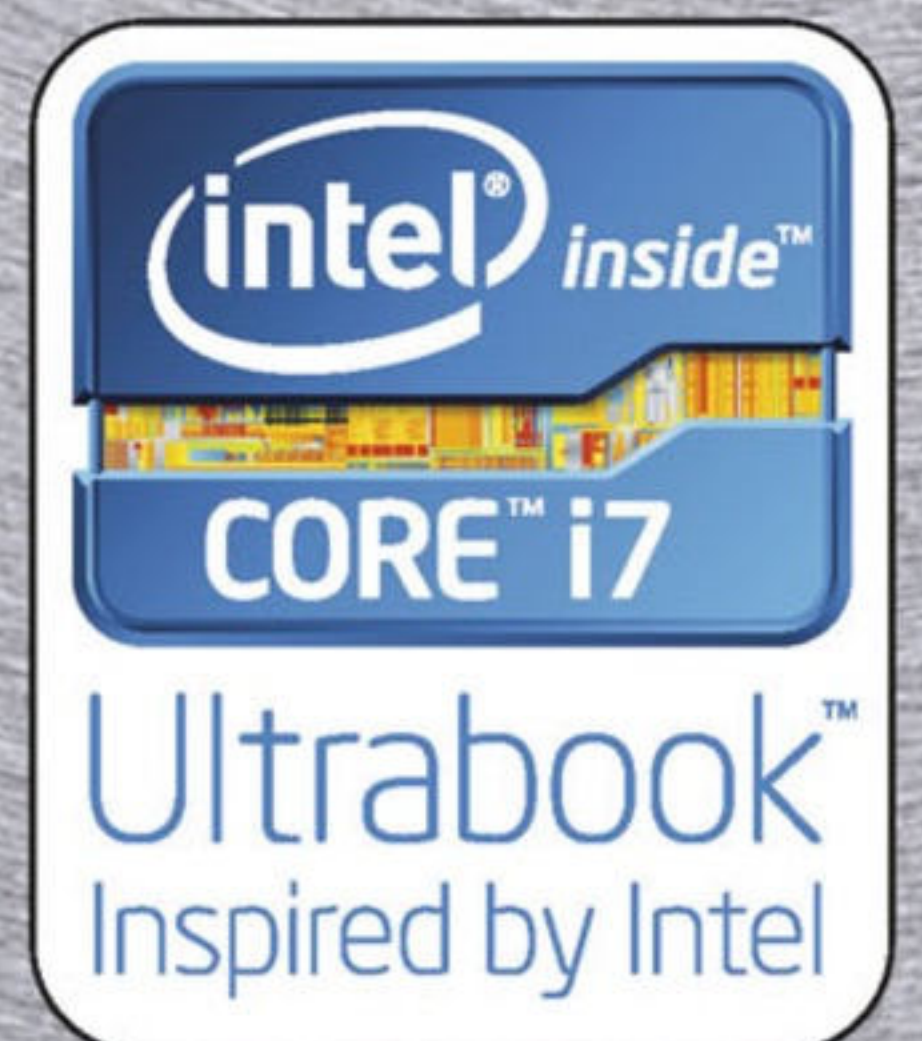
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Already a subscriber? On page 34 you'll find an interview with graphene guru Konstantin Novoselov



According to science, being bad can sometimes be good for you. Strange as it seems, behaving in a devious manner can help you get ahead at

work, in your relationships, and keep you healthier. Luis Villazon covers the results of several scientific studies in his eye-opening feature on page 38. No more Mr Nice Guy? Personally, I'd be hesitant... being editor of *Focus* is more than good enough for me.

From one kind of incredible to another: resurrecting the woolly mammoth sounds every bit as implausible as the technology in *Jurassic Park*. In reality, it's a genuine possibility now that well-preserved mammoth tissue has been found. Turn to page 60 to read Henry Nicholls' report.

In the course of history, a select few people could truly be said to have been touched by genius: Galileo Galilei, Charles Darwin and Albert Einstein are among them. But there's another – a man so extraordinary he achieved greatness in a number of fields. Leonardo da Vinci wasn't just an incredible artist and inventor. He dabbled in anatomy too, and his pioneering studies are set to go on display in The

Queen's Gallery, Buckingham Palace. We took BBC science presenter and former medic Michael Mosley to a special exhibition preview. On page 52, he tells us what da Vinci discovered before anybody else, 500 years ago.

Another man ahead of his time was Barron Hilton, son of Conrad, founder of the global hotel empire. It's 45 years since Barron spoke to a space conference to outline his plans for a Hilton on the Moon. We catch up with the octogenarian this month to ask if he still believes space hotels are just around the corner.

A more sobering anniversary falls on 15 April. It's 100 years since the Titanic, supposedly built to survive impacts, was lost in the north Atlantic. So are we any nearer to building an unsinkable ship? Paul Eastaugh explores the latest in marine technology on page 66.

Last but not least, keep an eye out for next month's issue, which will take a look at one of the great mysteries of science.

Graham

What I've found out this month

- There's a real place called Pleistocene Park! (p60)
- Brewers are on the cusp of making more stomach-friendly beer (p21)
- Life could be discovered on other worlds by measuring reflected light (p24)

Experts



Paul Eastaugh

Paul Eastaugh is a journalist specialising in marine technology, who has written for all the leading shipping industry publications. On page 66, he looks at the advances that are making ships safer.



Michael Mosley

A qualified physician, these days Michael is a full-time journalist and broadcaster specialising in medical matters. He examines Leonardo da Vinci's legacy in the field of anatomy on page 52.



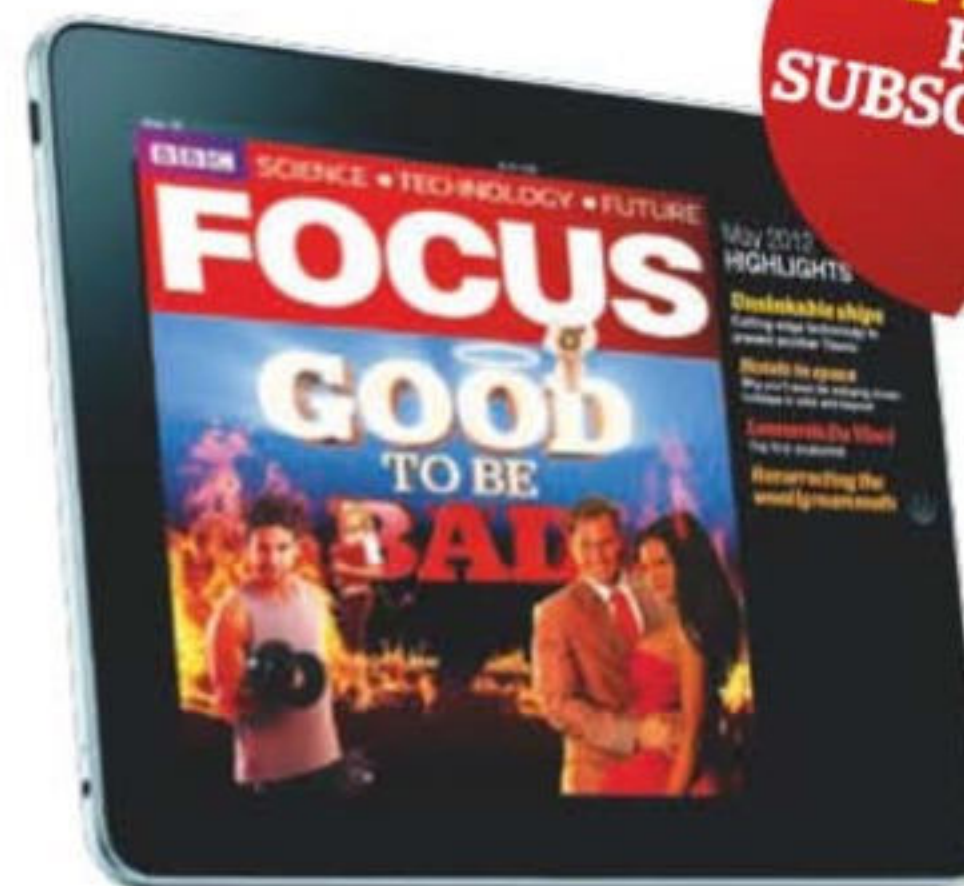
Bill Oddie

The presenter of BBC wildlife programmes such as *Springwatch*, Bill Oddie is a successful musician, writing hits like Funky Gibbon. He was perfect to review 'The Great Animal Orchestra'.



Kate Ravilious

Geologist Kate has been writing about science for leading magazines and broadsheets for over a decade. On page 70, she looks at recent advances in the treatment of malaria.



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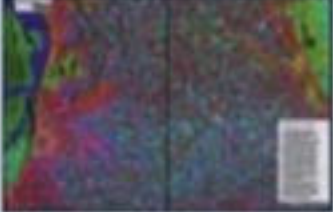
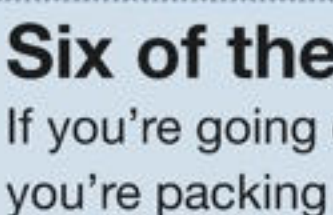
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"Seeing a group of mammoths walking out across the Siberian tundra was really quite moving"

Dr Alice Roberts on the making of *Mammoth*, p63



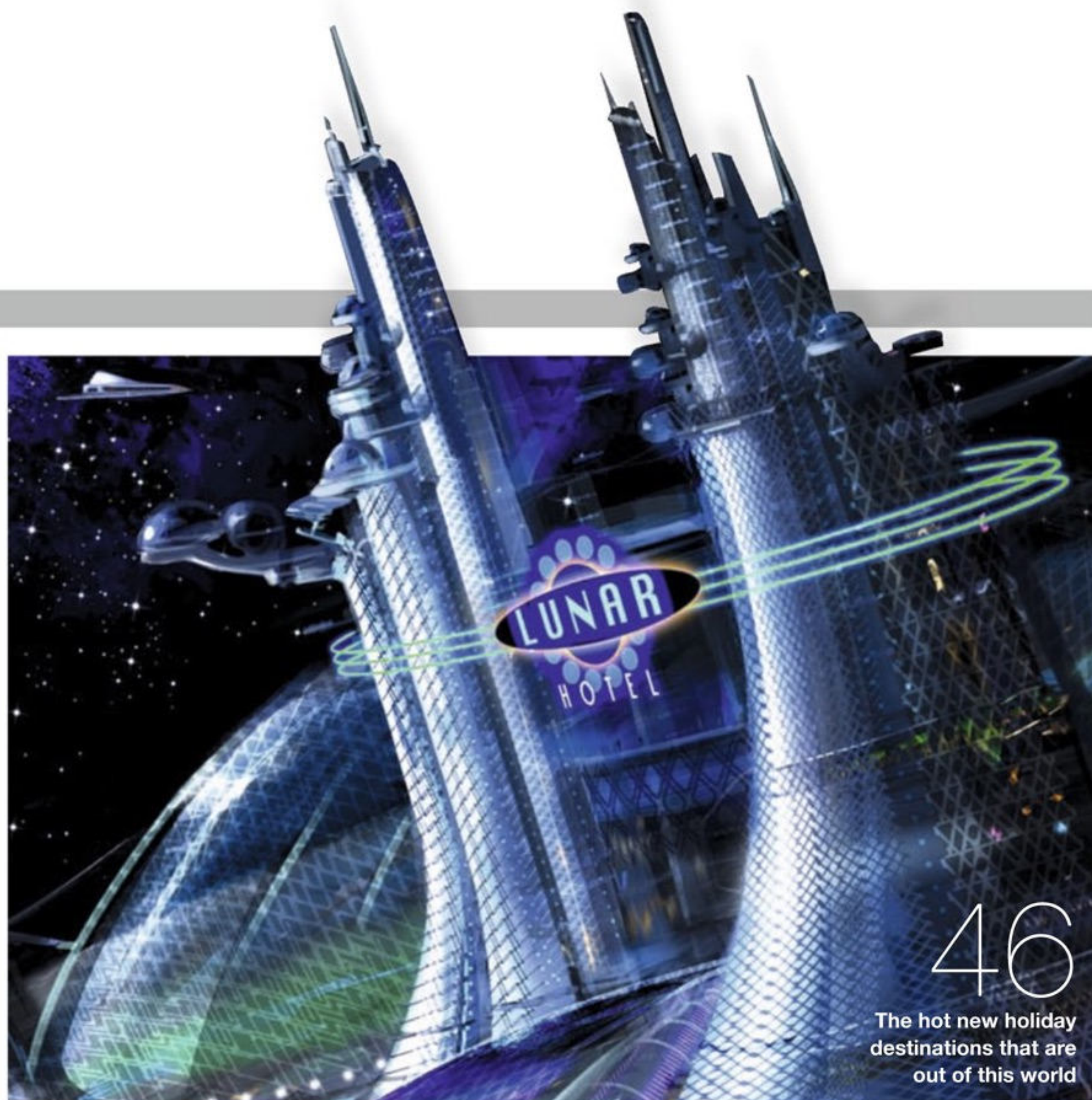
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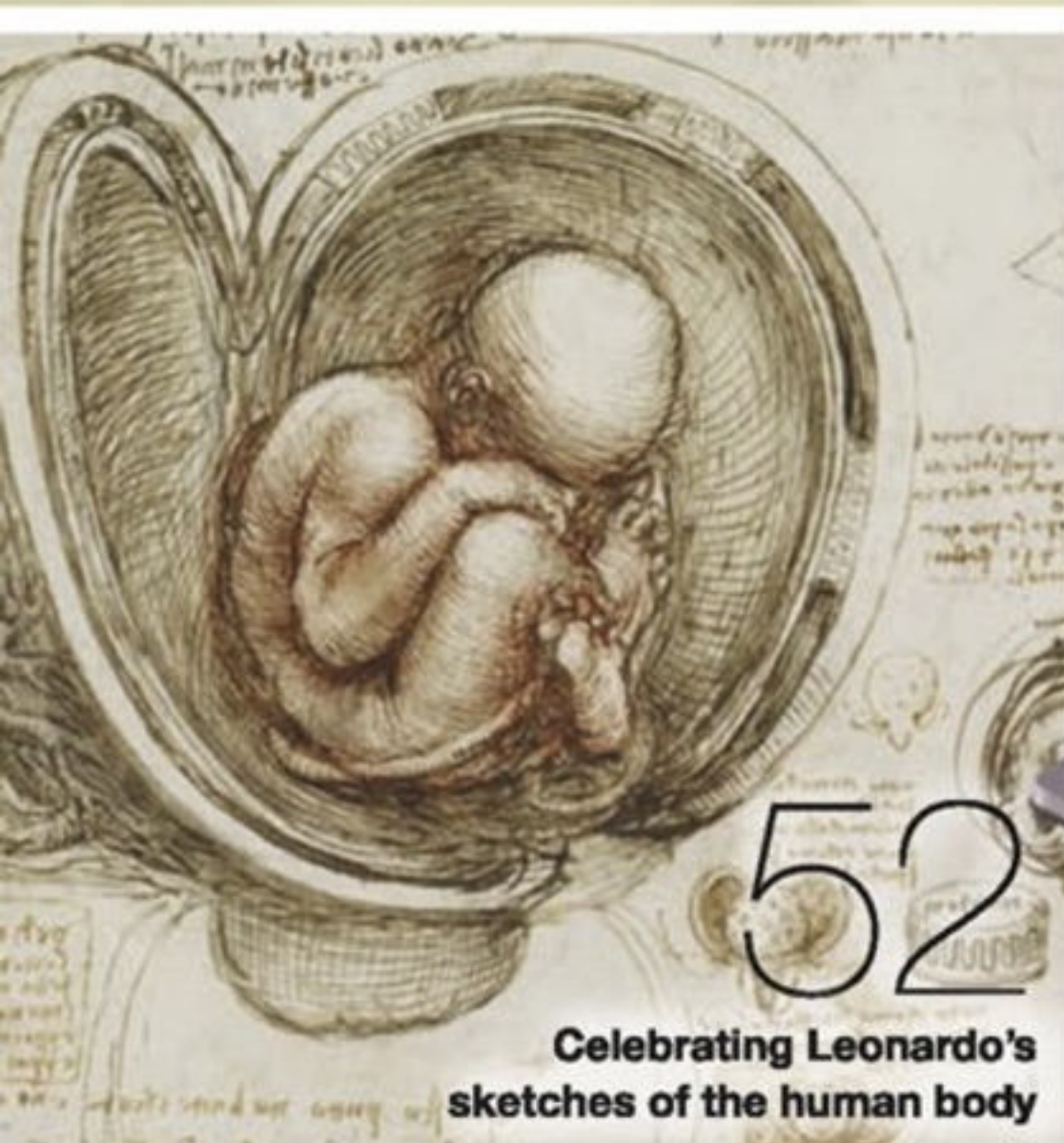


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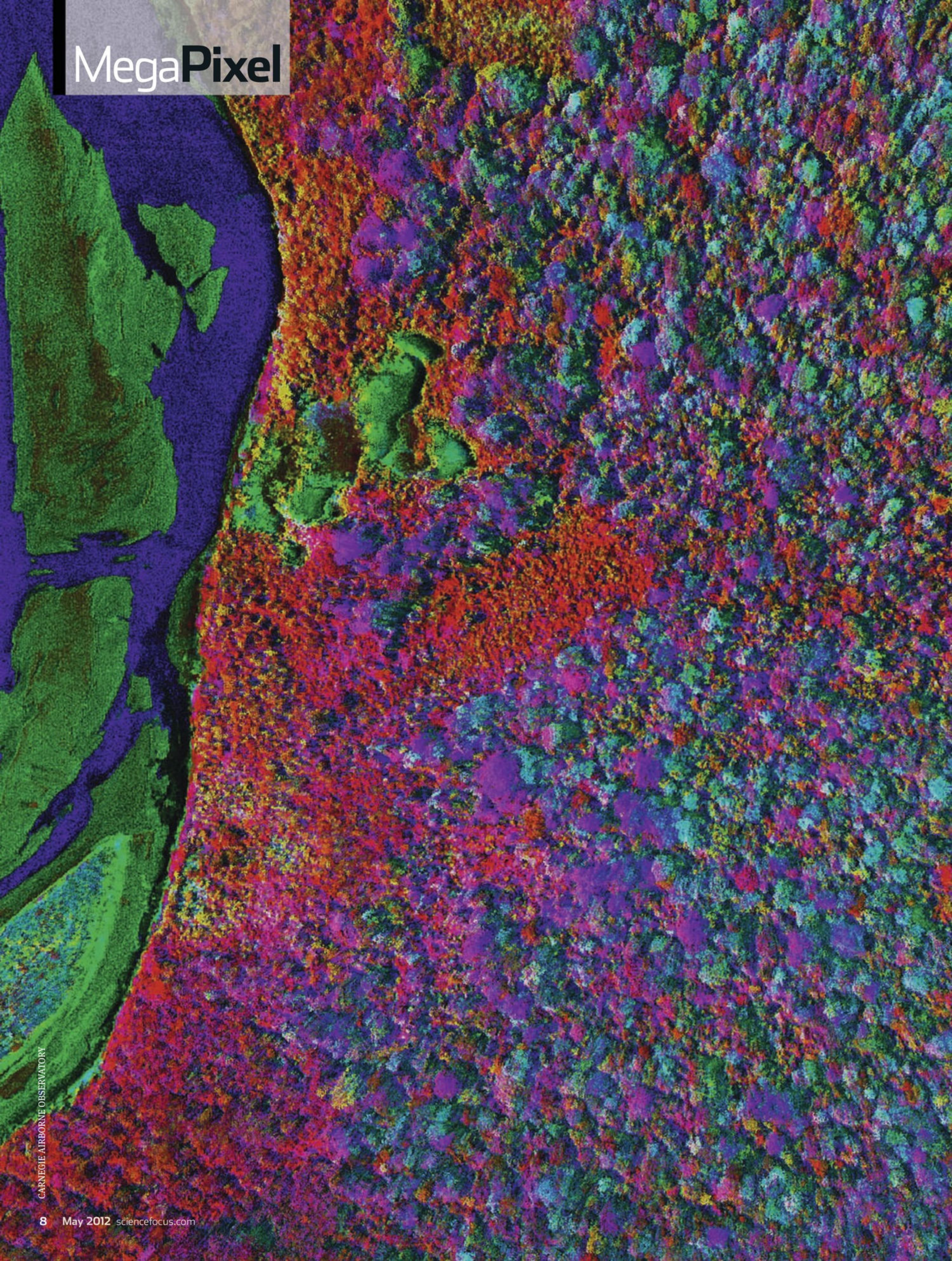


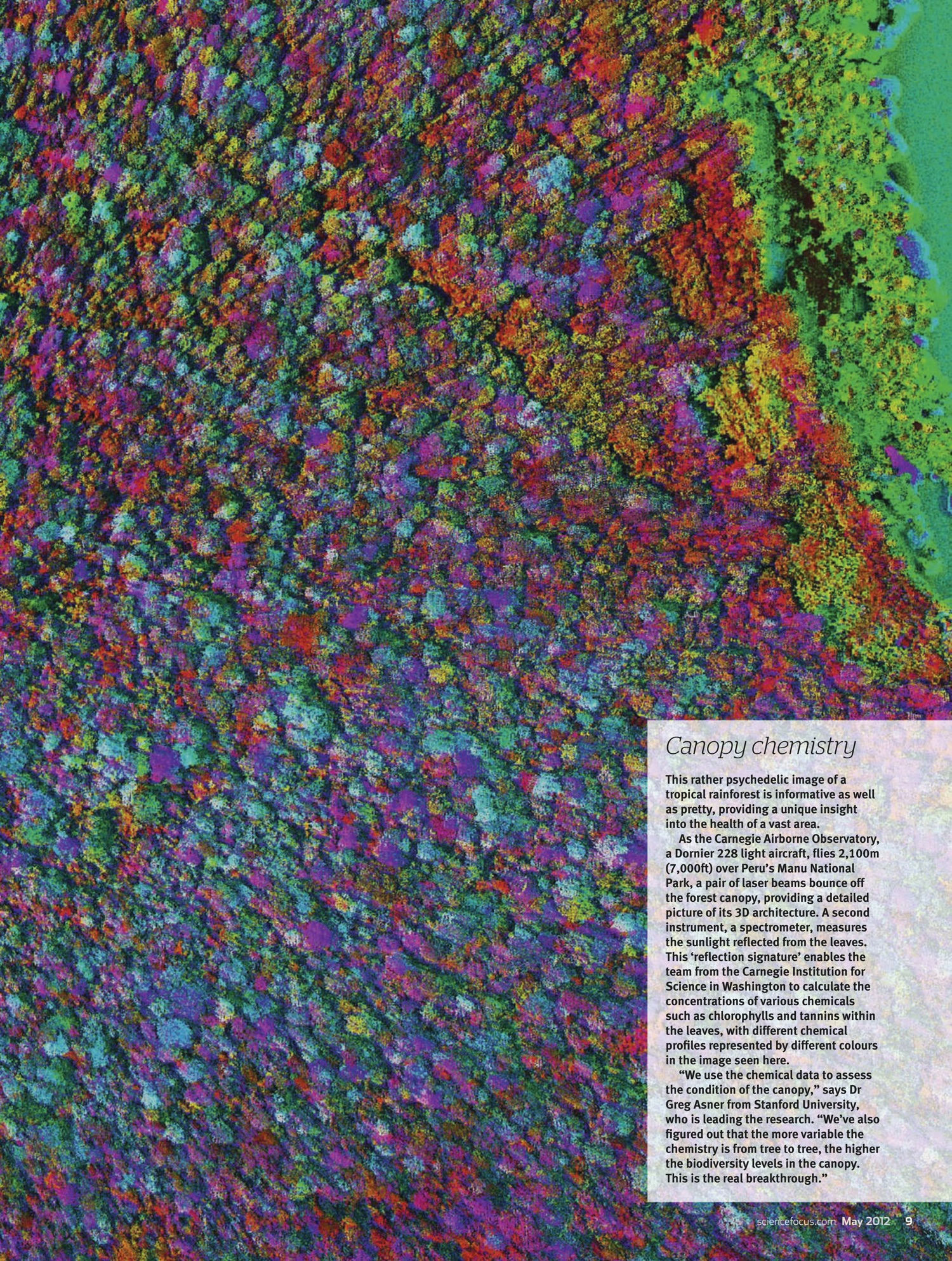
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Canopy chemistry

This rather psychedelic image of a tropical rainforest is informative as well as pretty, providing a unique insight into the health of a vast area.

As the Carnegie Airborne Observatory, a Dornier 228 light aircraft, flies 2,100m (7,000ft) over Peru's Manu National Park, a pair of laser beams bounce off the forest canopy, providing a detailed picture of its 3D architecture. A second instrument, a spectrometer, measures the sunlight reflected from the leaves. This 'reflection signature' enables the team from the Carnegie Institution for Science in Washington to calculate the concentrations of various chemicals such as chlorophylls and tannins within the leaves, with different chemical profiles represented by different colours in the image seen here.

"We use the chemical data to assess the condition of the canopy," says Dr Greg Asner from Stanford University, who is leading the research. "We've also figured out that the more variable the chemistry is from tree to tree, the higher the biodiversity levels in the canopy. This is the real breakthrough."





The life bank

In a room maintained at exactly 22°C hang hundreds of bags of donated blood. Each year, NHS Blood and Transplant's Filton Blood Centre in Bristol handles enough of the red stuff to completely replace the blood of over 85,000 people – that's roughly the population of Halifax or Hastings. It's the world's largest blood bank.

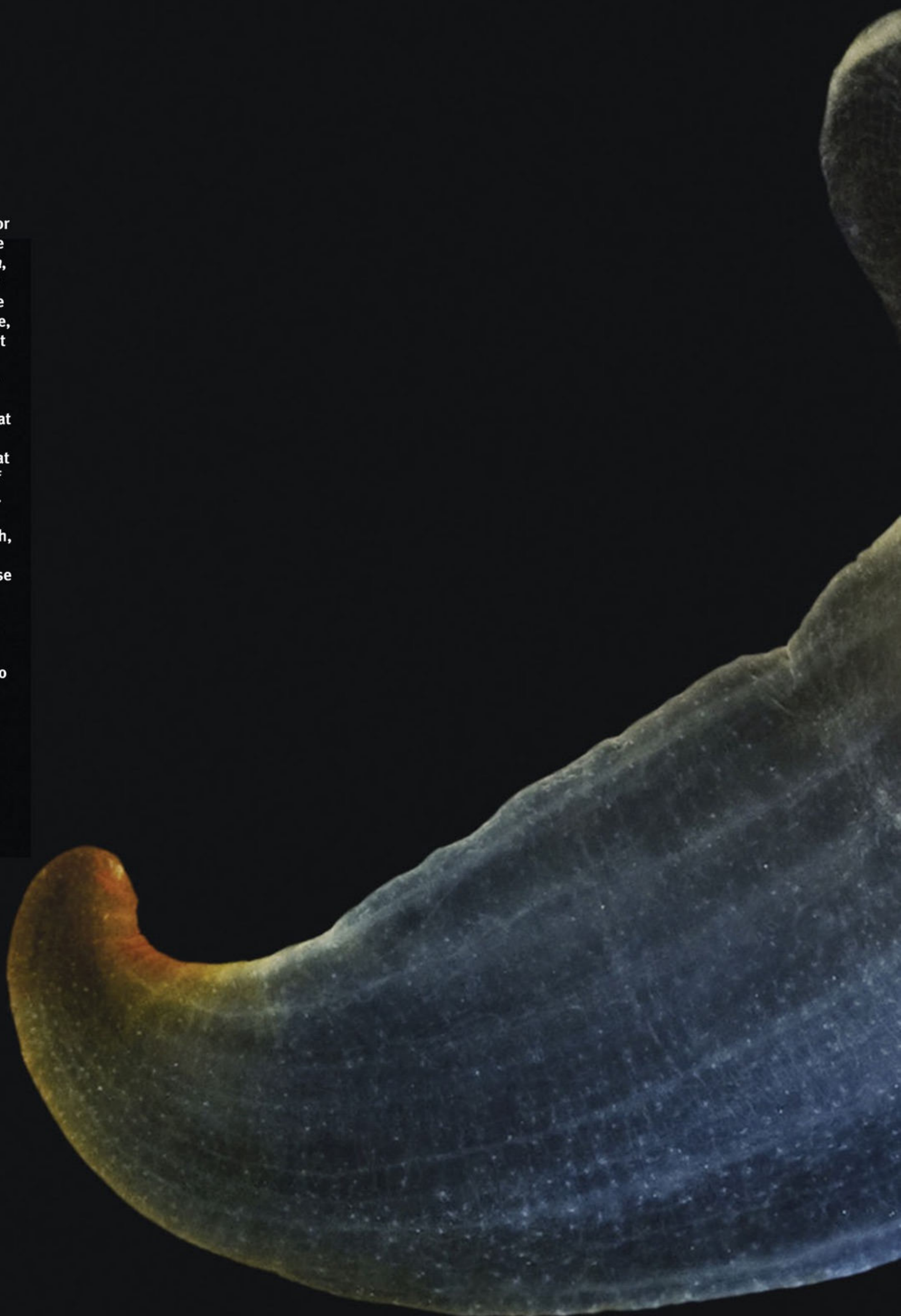
Blood from all over southwest England is delivered overnight. "It is kept at 22°C during shipment, and remains at 22°C while it's being treated – that's the optimum temperature to avoid it clotting," says the centre's manager, John Kirkwood.

First, the white blood cells are removed in circular filters. Part of the body's defence system, these are given to patients with life-threatening infections, to boost their immune systems. The remaining filtered blood is then separated into red cells and plasma. The former is given to patients who have suffered heavy blood loss, while the latter can help those who have been severely shocked or burned.

Angel of the north

This largely translucent undersea creature is something of an enigma: for much of the year, no-one knows where it lives. The sea angel, *Clione limacina*, predominantly inhabits the icy waters near the North Pole (although this one came from just outside the Arctic circle, in the White Sea in northern Russia). It makes its appearance in spring at the same time as its only food source, the sea butterfly. "For a few weeks, sea angels hunt sea butterflies, which all at once practically disappear," says marine biologist Alexander Semenov at Moscow State University. "A couple of weeks later, the angels disappear too. But no-one knows where they go."

Sea angels grow up to 5cm in length, and their wings allow them to swim much faster than sea butterflies, whose wings are less effective. The predator clasps its prey with its tentacles, rotating it until its shell opening is in the right position for hooks to be inserted. These hooks are then used to draw the hapless creature out before swallowing it whole.







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The latest intelligence

Need to know

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Robotic micro surgeons power up

Energy transfer discovery makes medical devices that travel through the bloodstream feasible



For 50 years, scientists have been trying to create tiny gadgets that travel around a patient's bloodstream, detecting and even fixing disease. But there has been one problem – how to power them. Now a new method of supplying energy to the miniscule machines means that the technology is perhaps just five years away.

While batteries have shrunk over the years, they haven't been miniaturised sufficiently to fit into a medical device small enough to travel through veins and arteries. So instead of using batteries, engineers at Stanford University in the US have developed tiny implants that can be powered by radio waves beamed from a transmitter outside the body.

"We have got very good at shrinking the electronic and mechanical components of implants, but energy storage has lagged in the move to miniaturise," says Stanford's Prof Teresa Meng.

The idea of using electromagnetic waves to transfer power to implantable medical devices is not new, and

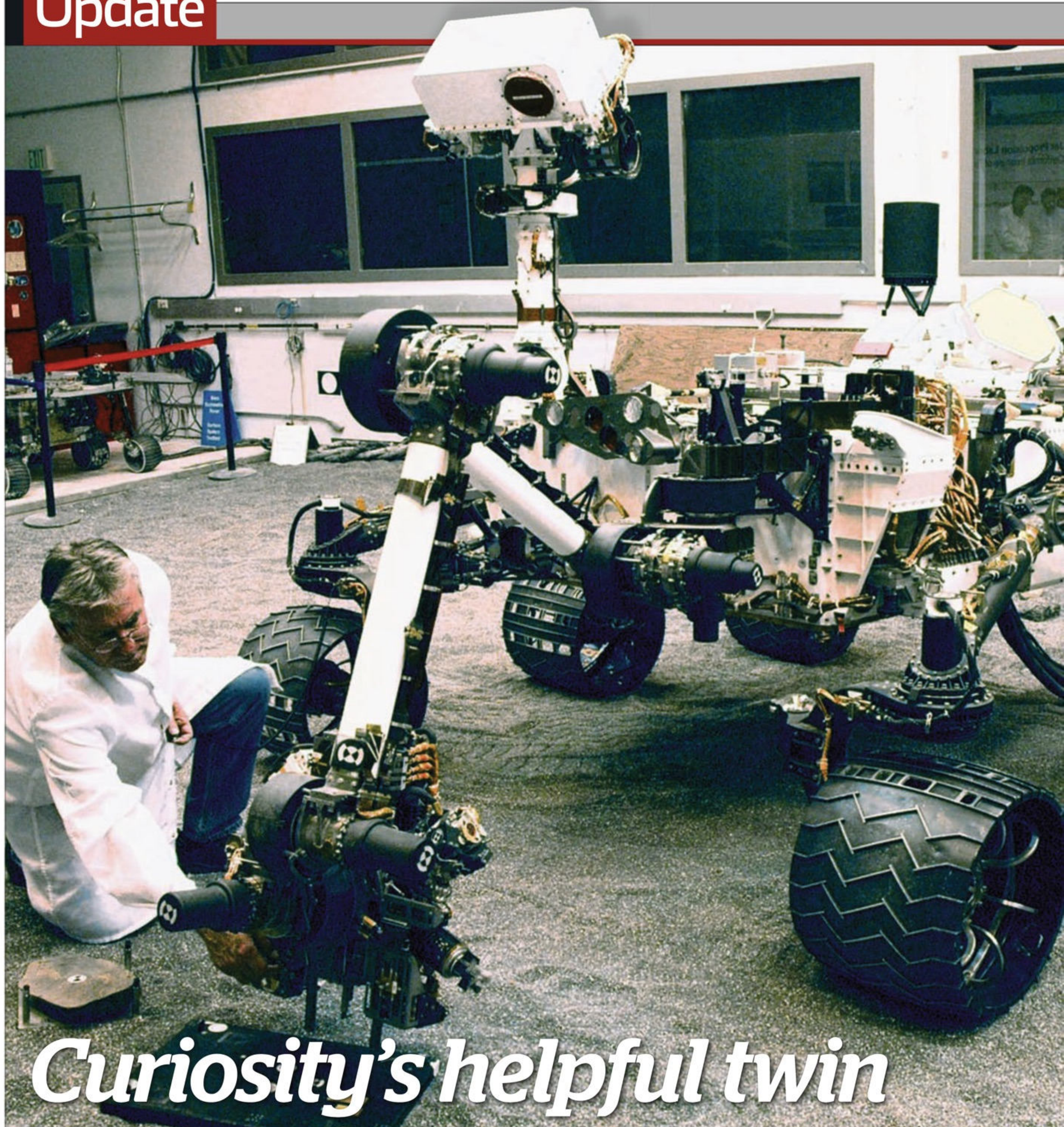
in principle it sounds simple. A transmitter outside the body emits radio waves that travel through the tissues. They are then picked up by an antenna on the internal device where they induce a voltage, powering the implant. The trouble is, scientists previously thought that radio waves would struggle to get through human tissue. But Assistant Professor Ada Poon at Stanford, who led the study, scoured research papers and found strong evidence that they do pass through. Poon then used a chunk of beef as a stand-in for human flesh and found that sufficient energy moved through it to make electromagnetic power transfer feasible.

Already, working prototypes that can propel themselves have been developed. But the distance power can be transferred inside the body still needs improvement. "We can build millimetre and sub-millimetre sized devices that can operate a few centimetres beneath the surface of the body," says Poon. Further development will hopefully generate devices capable of venturing a little deeper.

Multitasking machines

The devices being developed at Stanford University would be implanted or injected into the body and either be static – fixed at some point inside the recipient – or move through the bloodstream under their own power. "This device has been designed as a vehicle with a space for cargo. The application will define what it carries," says Assistant Professor Ada Poon at Stanford.

As sensors, the gadgets could be placed in parts of the body other such devices can't reach. Moving variants of the machines could also travel through the bloodstream until they reach the exact location where a drug is required, delivering their payload with precision. Or they could be used to guide existing medical equipment such as catheters.



Curiosity's helpful twin

This vehicle might look familiar. That's because it's an almost exact replica of NASA's new rover, Curiosity, which is currently well on its way to Mars. But while Curiosity will get to explore the Red Planet first-hand, the Vehicle System Test Bed (VSTB) will not leave Earth.

The VSTB will still perform a vital function though, allowing NASA scientists to check commands before they are sent to Curiosity, 570 million kilometres (354 million miles) away on the

surface of Mars. Here, in tests being carried out at the In Situ Instrument Lab at NASA's Jet Propulsion Laboratory in California, precision movements of the rover's robotic arm in response to instructions are being tested.

Dr John Grotzinger, project scientist for the Mars Science Laboratory mission, says the VSTB will be most useful for practising manoeuvres that have never been tried before. "Say we want to drill a rock, but the rock is not flat – we'd need

to first test out the drill on a rock with a sloping surface." The VSTB's arm is an exact copy of Curiosity's, as are its chassis and electronics. Its 10 instruments are either simulators or partial models of Curiosity's.

Curiosity lifted off from Cape Canaveral aboard an Atlas V rocket in November 2011 and will reach Mars on 6 August. It will then begin its investigations into whether the Red Planet is, or ever was, able to support microbial life.

1.3
metres

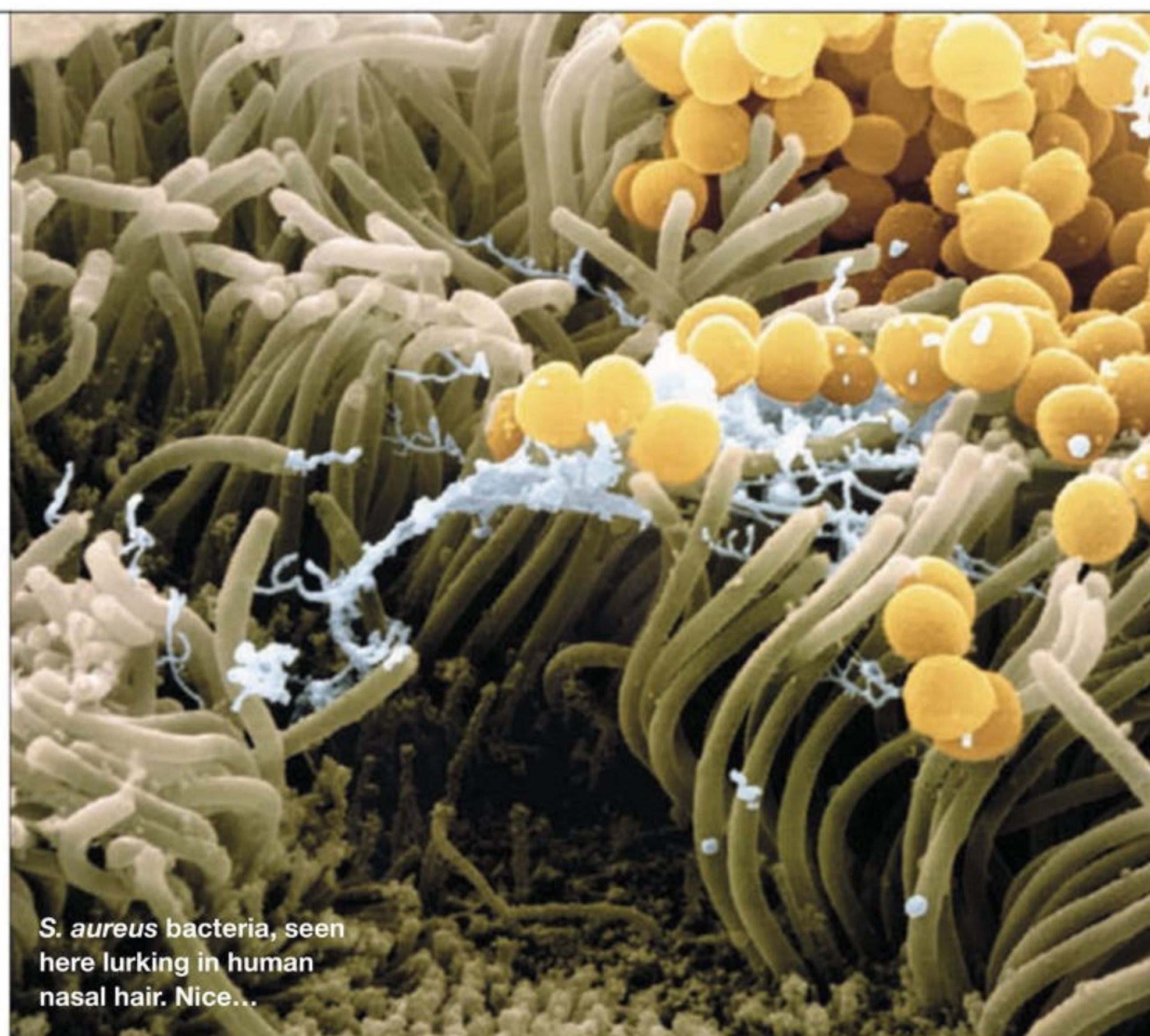
is how tall a penguin that lived in New Zealand about 26 million years ago stood. The penguin would have been 30cm larger than an emperor penguin.

31,800

years old is the age of a fruit that was used to regenerate the narrow-leaved campion plant (*Silene stenophylla*). The fruit was preserved in an ancient squirrel burrow in the Siberian permafrost.

16%

is how much the protein sirtuin has been found to extend the life of mice by Israeli scientists. Its anti-ageing effects appear only to apply to male mice.



S. aureus bacteria, seen here lurking in human nasal hair. Nice...

MRSA's foe: the avocado

Rainforest plant could hold the key to fighting antibiotic resistance

A chemical from a rare Chilean plant could combat MRSA, the antibiotic-resistant bacteria that is closing hospital wards and killing patients.

Chemist Jes Gitz Holler, a PhD student at the time, travelled deep into the Chilean rainforest with colleagues from the University of Copenhagen to hunt for plant chemicals that can stop bacteria from fighting off antibiotics. Guided by a traditional healer and a botanist, he gathered plants used by generations of local Mapuche people to treat wounds and skin infections.

Holler struck gold with a Chilean avocado plant (*Persea lingue*) in which he found a substance he called Compound 1. This had the effect of stopping a pump within the membranes of the MRSA bacteria (*Staphylococcus aureus*). The pump is able to expel antibiotics, rendering them useless.

"We collected a lot of species and screened them to see which had an effect," says Holler. "With the most promising we did bioassay-guided

isolation." In other words, plant extracts were separated into their component parts to see which were responsible for the bacteria-fighting effects.

S. aureus is the most common cause of infection in wounds following an operation. It can cause life-threatening infections such as sepsis, too. So when certain strains, called Methicillin-resistant *S. aureus* (MRSA), are able to fight off antibiotics, it's a big problem.

The next steps will be to discover whether Compound 1 is toxic inside the body, and the effect the digestive system has on it. If the molecule survives digestion, it could be taken orally before antibiotics. If it is broken down, it could be applied directly to a skin wound with antibiotic cream.

"To all intents and purposes, the drug industry is not pursuing research into new antibiotics," says Holler. "It is simply too expensive relative to possible earnings. So bacteria are winning the race. Research will have to find new paths, and natural substances are one of them."

A new form of aspirin may have reduced side effects because it releases nitric oxide and hydrogen sulphide, gases produced naturally in the gut.

Swiss researchers want to build a spacecraft to remove junk from orbit. CleanSpaceOne would drag dead satellites into a position where they re-enter Earth's atmosphere and burn up. There's now just the small matter of raising £7m to put it in space.

University of Nottingham food scientists investigating how crisps release their taste have discovered a 'salt burst' about 20 seconds after chewing begins – by which time many people will have swallowed the crisp. Speeding up the arrival of this salt burst could reduce the salt required for a tasty snack.

GOOD NEWS BAD NEWS

Children are getting 73 minutes sleep less each night than they were a century ago. Australian researchers studied over 213 reports on sleep made over the years to reach their conclusion. Recommended sleep times have dropped by 71 minutes over the same period.

A bacterium commonly found in the mouth could cause serious illness. *Streptococcus tigurinus* was isolated from the blood of patients suffering from conditions including meningitis and endocarditis. More research into the bacterium's MO is now needed.

Ambitious high achievers tend to live shorter lives, say researchers at the University of Notre Dame, Indiana, who studied over 700 people to reach their conclusion.

INSIGHT

Structural batteries

What are they?

Batteries that are part of the fabric of the device they power, rather than being a distinct unit. Saving both weight and space, they would allow cars to be powered by their bodywork and mobile phones to be powered by their own structure.

How do they work?

Just like normal batteries, they convert chemical energy into electrical energy. However, rather than having a distinct anode, cathode and electrolyte, these components take the form of a matrix of powders within the main structure. When they react together, the surrounding carbon fibre or other material conducts the charge to where it's needed.

Who's making them?

Defence company BAE Systems developed structural batteries to lighten the load of soldiers carrying electronic gear. So far, it has used the technology to build a torch and a small unmanned aerial vehicle. BAE has also been working with sports car maker Lola to develop batteries that would power the electronics in a Le Mans prototype racer.

Will we ever see these batteries in household devices?

The BAE prototypes use nickel-based chemistry. This gives the batteries a long life – suitable for military use – but a power density that's too low for consumer items. In the future, BAE hopes to develop lithium-based structural batteries that will store more power, and plans to incorporate the technology into lightweight fabrics. This could pave the way for tents and rucksacks with their own power supplies.



The Lola Le Mans prototype

ROUND UP

This month's top science stories from around the globe

PALAEONTOLOGY

Triceratops was no slouch

Rather than being splayed out to the sides like those of reptiles, as was previously thought, a triceratops' forelimbs were fairly upright. This suggests that the dinosaur was quite athletic. To deduce the triceratops' sprightly gait, scientists toured museums measuring the elbows of over 300 four-legged animals. They found that three main measurements can be used to reconstruct the creatures' forelimb postures more accurately than had previously been possible.

ATMOSPHERIC SCIENCE

Clouds are getting lower

Using data from NASA's Terra satellite, atmospheric physicists at the University of Auckland have shown that the globally averaged cloud height decreased by around 1 per cent (30 to 40m) between 2000 and 2010, due to fewer clouds forming at high altitudes. Lower and therefore warmer clouds will emit more thermal energy into space, reducing the planet's overall surface temperature and potentially offsetting some of the effects of global warming.

MEDICINE

Blood groups unmasked

Ever heard of the Langereis blood type? What about Junior? Well, the existence of these blood groups has been known for a while, thanks to bad matches causing transfusion problems. But the molecules in the blood responsible for determining whether people were positive or negative for these blood types was unknown. Now two molecules named ABCB6 and ABCG2, which sit on red blood cells, have been identified. This will make screening for these blood groups possible.

GENETICS

Gorilla genome published

The DNA of gorillas has been sequenced, allowing the genomes of all four living great apes, which also include humans, chimpanzees and orangutans, to be compared for the first time. The research shows that there are several parts of the gorilla genetic code which have evolved along the same lines as that of humans. Among the areas of parallel genetic change is hearing, an interesting insight because it had always been assumed that the evolution of human hearing genes had been influenced primarily by the evolution of language.

ASTRONOMY

Dust devil caught on camera

It looks like a smoke signal rising from the surface of Mars, but the grey plume (right) is actually a dust devil. The swirling column of air was made visible by the dust it kicked up and was captured by the HiRISE camera aboard NASA's Mars Reconnaissance Orbiter in the Amazonis Planitia region. The column would have formed when heated air near the planet's surface began to rotate as it rose. It was nearly 1km (0.6 miles) tall when imaged, its development aided by the Red Planet's low gravity.

PHYSICS

Atomic bonding captured

It's the stuff of basic chemistry lessons – how atoms combine to form molecules. But now physicists in the US have been able to get the most detailed picture yet of molecule formation, with the first 'image' of the process. They fired laser pulses at an atom to knock an electron out of its natural orbit. When the electron fell back into place, it emitted energy that scattered around the new molecule, revealing the locations of the constituent atoms' nuclei and electron shells.





A discovery revealing which components of beer most stimulate acid production in the gut could lead to the development of more stomach-friendly brews.

Beer stimulates the release of stomach acids, too much of which can lead to ulcers and acid reflux. It has also been established that several compounds, including the alcohol, are responsible for that stimulation.

Now, chemists at the University of Vienna have analysed an overlooked group of bitter acid compounds from hops, extracted from German and Austrian brews. They found that these acids had a potent effect, stimulating gastric acids at much lower concentrations than other compounds.

NEWS IN BRIEF

The male response to stress may be controlled by one gene. When the pressure is on, men show the classic 'fight or flight' response, including increased heart rate and blood pressure. In women, the immediate response is the same, but this tends to decline over time, replaced by a tendency to seek social support. The SRY gene, found only in males, was known to be involved in testes development. But it is now thought the protein it forms may also prime organs for the stress response.

Saturn's moon Titan shares many features with Earth, including clouds, rainfall and lakes, but new studies by NASA's Cassini probe have revealed similarities with the seasons too. Astronomers have been able to piece together seasonal changes that took place on the moon over five years. The results showed a vast cloud of ethane hanging over the north pole, thinning out and retreating as winter turned to spring.

We're now closer to understanding how insects fly, thanks to experiments showing how hovering bodies maintain their balance. To mimic the turbulent airflow around flapping wings, researchers at New York University placed pyramid-shaped paper 'bugs' in an oscillating column of air. They found that top-heavy bugs were more stable than those with a lower centre of gravity – a feature that could be exploited in the design of hovering aircraft.

Hollow spheres of carbon atoms known as buckyballs have been spotted floating as solids in space. Previously, they had only been seen floating freely as a gas. Astronomers were able to detect the solids 6,500 light-years away using NASA's Spitzer Space Telescope, as they emit light in a way that's different from the gaseous form. The discovery shows that buckyballs are more common in space than once thought, and could be an important source of carbon, a key building block for life.



This Martian dust devil rose to almost 1km in height



Gorillas share many genetic traits with human beings

MARINE BIOLOGY

Fish fright signal discovered

When a fish is injured, chemical signals can trigger fear responses in entire shoals. Now researchers in Singapore have discovered that sugar-like molecules released in mucous from fish skin are the key to this response. Zebrafish exposed to a sugar polymer in the mucous called chondroitin-6-sulphate displayed classic fear behaviour: darting, slow swimming and bottom-dwelling. The chemical registered in the scent-processing region of the zebrafish brain.

PSYCHOLOGY

Wanted: man of war

At times of war, we prefer our leaders to have masculine-looking faces, regardless of whether they're male or female. Scientists at VU University in Amsterdam made the discovery by showing 118 people four kinds of face – masculine and feminine versions of both male and female faces – before asking who they'd vote for to be president at times of war and peace. Hormones are likely to be behind these decisions. Higher testosterone levels tend to lead to masculine facial features but also stimulate aggressive behaviour.

Rain: key to a calm planet

Raindrops can have a surprising influence on the global climate. Atmospheric scientists have calculated that, taken together, falling raindrops dissipate so much of the atmosphere's energy that they have a calming effect on winds around our planet.

"The idea of energy dissipation through rainfall was originally proposed 12 years ago," says Olivier Pauluis at New York University. "This is the first time that it has been obtained from observations."

Winds are created as the Sun heats the Earth: as warm air near the ground rises,

some of its heat is lost as kinetic energy, generating movements ranging from large scale jet streams to small gusts. Turbulence occurs as air molecules move around and rub against one another, and some of that energy is dissipated as heat. But now it seems that rainfall is also a significant factor.

As each raindrop falls, a small amount of friction is generated, again dissipating energy as heat. Scientists at New York University and the US National Oceanic and Atmospheric Administration took data from NASA's Tropical Rainfall Measuring Mission satellite, which

uses radar to calculate how much rainfall is falling over the tropics. Using this, they calculated the total drag experienced by all the droplets and from this the energy dissipated. Globally, says the research team, the total rate of energy dissipation from precipitation is around 10^{15} Watts – roughly 100 times the rate that humans consume energy worldwide.

Climate models predict that a warmer world will have more rain, so this newly found energy dissipating effect is only likely to grow.

Spider silk's hot new ability

It's incredibly strong and flexible, but now another property can be added to spider silk's ever-growing list of abilities – it is an excellent conductor of heat.

Mechanical engineer Dr Xinwei Wang at Iowa State University found that the fine threads spun by the golden silk orb-weaver (*Nephila claviceps*) conduct heat at the rate of 416 Watts per metre Kelvin, or 'k' – an exceptionally high figure for an organic material. In comparison,

iron transfers heat at a rate of 55k. Strangely, the heat conductivity increases when silk is stretched – the opposite is true for most materials.

The spider silk's molecular structure is thought to be behind its conductivity, although the causes need further investigation. It means it could form the basis of flexible heat-dissipating parts for electronics, and more comfortable clothes for hot weather.

LOOK BACK

60 YEARS AGO
British electronics engineer Geoffrey Dummer describes the concept of the microchip for the first time at the US Electronic Components Symposium in Washington DC. He envisions multiple circuit elements embedded in a substance such as silicon.

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Reflected light to reveal habitable worlds

It's official: there's life on Earth. This is clearly not news to any of us, but the technique astronomers used to show that our planet is occupied by living organisms *is*, and could be applied to worlds outside our Solar System.

Studying the light reflected from an extrasolar planet to reveal what it's like is usually impossible – its reflected light is drowned out by the light from its star. But the new technique exploits the fact that while the light from a star is unpolarised – the waves vibrating in a multitude of dimensions – the light reflected from a planet is polarised, vibrating in a certain plane.

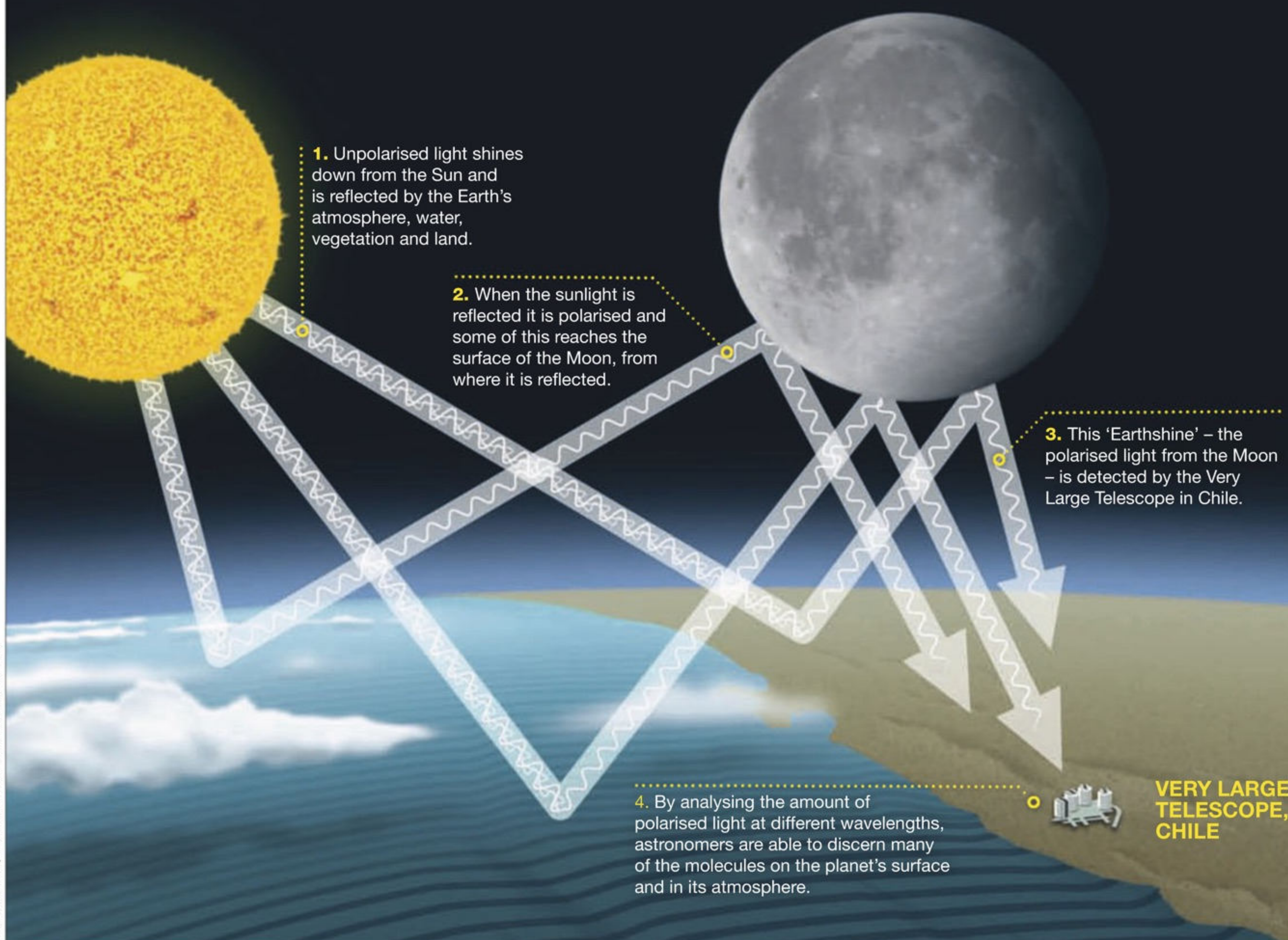
A team of astronomers, led by the European Southern Observatory's

Michael Sterzik, used the Very Large Telescope in Chile to analyse the light reflected from Earth. Some of the light reaches the Moon and is again reflected – known as Earthshine. They discovered that by analysing the amount of polarised light at different parts of the electromagnetic spectrum in this Earthshine, the presence of molecules like chlorophyll, oxygen or water can be revealed.

"There would have been reduced polarised light at certain wavelengths," says astrophysicist Dr Chris Lintott, co-presenter of BBC TV's *The Sky at Night*. "This would have revealed what's on Earth's surface and in the atmosphere."

If the polarised light was from an extrasolar planet, the make-up of its surface and atmosphere would be revealed. So far, 760 extrasolar planets have been discovered, but the composition of the atmospheres of only a small proportion have been analysed – those planets which pass directly between their parent star and the Earth, blocking out their sun's light. But the polarised light technique would unlock the characteristics of the other planets.

It may be a while before astronomers are able to do that, though. The light reflected from these distant worlds is too faint to be analysed by today's telescopes.





Should we be drilling into an active supervolcano?

During prehistoric times, cataclysmic eruptions at one or other of the world's supervolcanoes devastated huge tracts of our planet and, on one occasion, may even have brought the human race to the brink of extinction. You might think that drilling into one of these monstrous volcanoes isn't a great idea. Such a move would seem, at the very least, to be tempting fate. This, however, is exactly what a European consortium of scientists is about to do in southern Italy.

Opposition from many citizens and local politicians, who fear that the drilling may trigger an eruption, has resulted in repeated delays to the project. Now, though, scientists appear to have allayed these fears, at least as much as they could ever hope to. So all is set for a pilot borehole to slice 500m (1,640ft) down into the Campi Flegrei supervolcano near Naples in the late spring, with the drilling of the main 3.8km (2.4 mile) borehole following in the summer.

Campi Flegrei is not the volcano that everyone associates with the city of Naples. Whenever the ground has rumbled in the past, the eyes of its residents have inevitably turned eastwards towards the brooding double peak of Vesuvius, rather than to the west, where Campi Flegrei sits. This all changed in the late 1960s and early 70s, however, when swarms of earthquakes and the bulging upwards of the crust resulted in the giant volcanic crater joining the ranks of the so-called 'restless' calderas, others of which include Long Valley in California, the Greek island volcano Santorini, and Yellowstone in Wyoming.

There is still an enormous amount we don't know about supervolcanoes – in particular, how such stupendous volumes of magma can gather together and then be released in one massive volcanic burp, rather than in dribs and drabs. We also don't have very good handles on how rapidly the magma accumulates, nor how quickly it makes its way to the surface. Most critically, we are not sure what warning signs we might expect to see before a super-eruption, or how far in advance they would become apparent.

The aim of the drilling campaign is to try and answer these questions, and more. The researchers hope to build a detailed picture of



There is an enormous amount we don't know about supervolcanoes

Campi Flegrei's innards and the nature of the volcanically heated circulating waters that might play a role in the unrest. Sensors lowered down the borehole will provide measurements on the mechanical properties of the volcanic rock, including its permeability and temperature, and monitor future changes in those properties that might herald an eruption.

Extracted samples will also enable the hidden products of past eruptions to be catalogued. Although Campi Flegrei's last eruption, in 1538, was pretty small, its greatest prehistoric blasts were titanic. Today, such an event could threaten the lives and livelihoods of several million people.

With this in mind, should volcanologists be taking the risk of poking this sleeping giant? Could their interference actually provoke an eruption? There is precedent for magma coming

up a borehole. In Iceland in 1979, magma moving deep underground encountered a kilometre-deep borehole drilled to tap geothermal energy. Around three tonnes of fluid basalt spluttered out of the top of the hole before the magma congealed and blocked the conduit. The magma lurking below Campi Flegrei, though, is much stickier and deeper underground, so the chances of any managing to squeeze up a thin tube nearly 4km long to reach the surface are vanishingly small.

In short, drilling into a supervolcano is a bit like sticking a drawing pin into an elephant's backside, and can be expected to have a similar effect – none at all. There's a very good chance that Campi Flegrei will host another cataclysmic eruption – but not this year.

WHAT DO YOU THINK?

Is drilling into a supervolcano a vital piece of scientific research, or dangerous folly?
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The Analyst Robert Matthews

If scientists want people to listen to them, it's time for them to get touchy-feely

Scientists aren't known for their emotional outbursts, but they're quite capable of throwing a wobbly in private. I found myself pinned in a corner by one red-faced boffin recently: "These people just won't listen. They're complete idiots!" he fumed. "They're simply not interested in the evidence!"

The evidence in question concerned bisphenol A (BPA), a chemical used to make many plastic products such as polycarbonate baby bottles. Introduced decades ago, these are far safer than glass ones, for reasons obvious to anyone daft enough to let a baby play with glass. Or are they? There's now mounting concern about the potential health effects of BPA, which can affect hormone behaviour.

The key question is whether the BPA in plastic products ever gets into the body at levels high enough to pose a real health

risk. A quick search of the web suggests the answer is a scarily loud 'yes'. Many media stories report research claiming to have found links between exposure to BPA from consumer products and health effects ranging from heart disease and diabetes to behavioural changes in kids.

The thing is, of course, that the media tends not to report studies that find nothing to worry about. What's really needed is what scientists call a 'systematic review', that looks at all the studies and considers their strengths and limitations before reaching a conclusion. Indeed, it's already been done for BPA by scientific bodies such as the European Food Safety Authority. And they've concluded that BPA levels from plastic products are nothing to worry about.

That hasn't stopped consumer groups and health campaigners calling for

“
It turns out that telling people they're irrational if they don't accept the evidence doesn't work
”

BPA to be outlawed in baby bottles. The campaigns have succeeded in some countries; ask why, and you'll hear talk of the so-called Precautionary Principle, which is often taken to mean that even the merest whiff of risk should not be tolerated. It doesn't mean that – not least because of the danger of unintended consequences. In the case of BPA, for example, a ban could lead to a resurgence of serious injuries from broken glass.

It was all this unscientific, irrational malarkey that was frying the brain of my scientist friend. Just what do you have to do, he asked, to get some evidence-based sense back into the debate? So I told him: stop banging on about evidence, and start learning something about the touchy-feely idea of 'risk communication'.

Since the 1990s, a whole academic discipline has sprung up to establish what it takes to get people to choose hard evidence over scare stories or complacency. It turns out that telling people they're irrational if they don't accept the evidence doesn't work. You first have to show you understand people's concerns, then build up trust. Which makes sense: to take any evidence seriously, you have to trust the source. The irony of all this is that scientists aren't persuaded by mere evidence, either. You might think you have compelling evidence for something, but if you publish it in an obscure journal or come from a little-known university, good luck in convincing fellow scientists to take it seriously. From continental drift to cancer-causing viruses, the history of science is full of great ideas initially rejected because of a lack of trust among fellow researchers.

Sometimes, I can't help feeling scientists would benefit from regular reminders that they're not as different from everyone else as they think.





The Eco-sceptic Tom Heap

Little green aliens have arrived in the Antarctic

The scientific Unique Selling Point of the Antarctic, the continent's isolation, is under siege. Invasive plants are getting a free ride on visitors' clothing, and climate change is helping them to survive. Research published in the journal *Proceedings of the National Academy of Sciences* describes how a sample of tourists, scientists and ship's crew were combed and vacuumed to recover bits of alien vegetation from their clothing, boots and bags – apparently Velcro is an almost perfect seed trap. The microscopic hitch-hikers were then counted and, where possible, identified.

The result: an estimated total of 70,000 propagules – bits of plant which could grow – arrive on those frozen shores every year. What's worse, slightly more than half of them come from species which can survive in a cold climate. Many polar scientists work at both ends of the world, and visitors tend to be wealthy and adventurous types who may well have travelled to high latitudes or altitudes.

The researchers also found that while tourists were carrying an average of 9.5 seeds per person, the figure for scientists was considerably more. Scientific staff are likely to have spent more time in the field elsewhere than tourists, and less likely to have bought new kit for the trip.

There is little local competition for the invading plants. Aside from mosses and lichens, the Antarctic mainland

only has two plant species: *Deschampsia Antarctica*, a kind of grass, and *Colobanthus quitensis*, the pearlwort. The grass *Poa annua* presents a prime example of the threat posed by invaders. After being accidentally introduced at the Polish Arctowski research station on King George Island (exactly how is not clear), it is now growing at three points on the mainland.

What makes matters worse when it comes to invasive plants is that the most visited

area of the continent, the Antarctic

Peninsula, has seen temperatures rise by an average of 3°C in the last three decades. At any point in history, strong winds

or migratory birds could have dropped something off but the climate was too harsh for

survival. Now our emissions and our inquisitiveness have changed all that.

The British Antarctic Survey, which was a partner in the new research alongside South Africa's Stellenbosch University, offers zero tolerance to aliens. Planes are sprayed, containers fumigated and instructions given to keep ship portholes closed. Any intruders – plant or animal – that do slip through are killed, bagged and shipped back to Britain for a post-mortem.

The Antarctic Treaty system is issuing strict guidelines for scientists and visitors. Boots must be scrubbed, pockets turned out and camera tripod legs bathed in biocide. These rules must be followed or the Observer Effect, the scientific folly whereby study itself alters the reality, could take root across a continent.



MEET THE COLUMNISTS

The Insider Henry Gee

A senior editor of the respected science journal *Nature*, Henry is the author of several books, including *The Science Of Middle Earth*.

The Eco-sceptic Tom Heap

Tom is an expert on all things green. He presents *Panorama* on BBC One and *Costing The Earth* on Radio 4, which questions accepted truths on green issues.

The Analyst Robert Matthews

After studying physics at Oxford University, Robert became a science writer. He is a visiting reader in science at Aston University.

The Medic Michael Mosley

After training as a doctor, Michael joined the BBC to become a presenter, writer and producer. He's *The One Show's* science man and presented *The Story of Science*.



The Medic

Michael Mosley

I'm learning to forget what I've been taught

On my first day at medical school, 100 of us gathered in a lecture theatre to be greeted by the Dean. He talked for a while, but there were only two things he said that I remember.

The first was that, based on previous experience, four of us in that room would marry each other. He was spot on – I met my future wife that day. The other thing he said was that, while we would learn a huge amount over the next five years, within 10 years of graduating as doctors much of what we had learnt would be out-of-date.

This was disheartening to hear at the time, of course, but the point he was making is that medicine is constantly changing. Unless you keep up, you are doomed to cling to outmoded ideas. I was thinking about this the other day, when I read a report in the journal *Nature Medicine* which suggested that it may, in the future, be possible to create human eggs.

I had been taught, and have duly repeated with great certainty in a number of television programmes I've subsequently made (most recently *Inside The Human Body*), that women are born with all the eggs that they will ever have.

Yet it turns out this may not be true after all. Dr Jonathan Tilly and his team at Massachusetts General Hospital recently managed to find and isolate a kind of human stem cell which, when grown in the lab, spontaneously turns into an oocyte, an immature egg.

When the same type of stem cells were taken from mice, the eggs they produced were fertilised with sperm and produced embryos. Dr Tilly told *Nature*: "I think it opens up the chance that sometime in the future we might get to the point of having an unlimited source of human eggs."

This discovery could prove to be extremely important for women who are infertile. It should also lead to yet another rewriting of the textbooks.

WHAT DO YOU THINK?

Has the science you learned at school passed its sell-by date?

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Monsters in our midst?

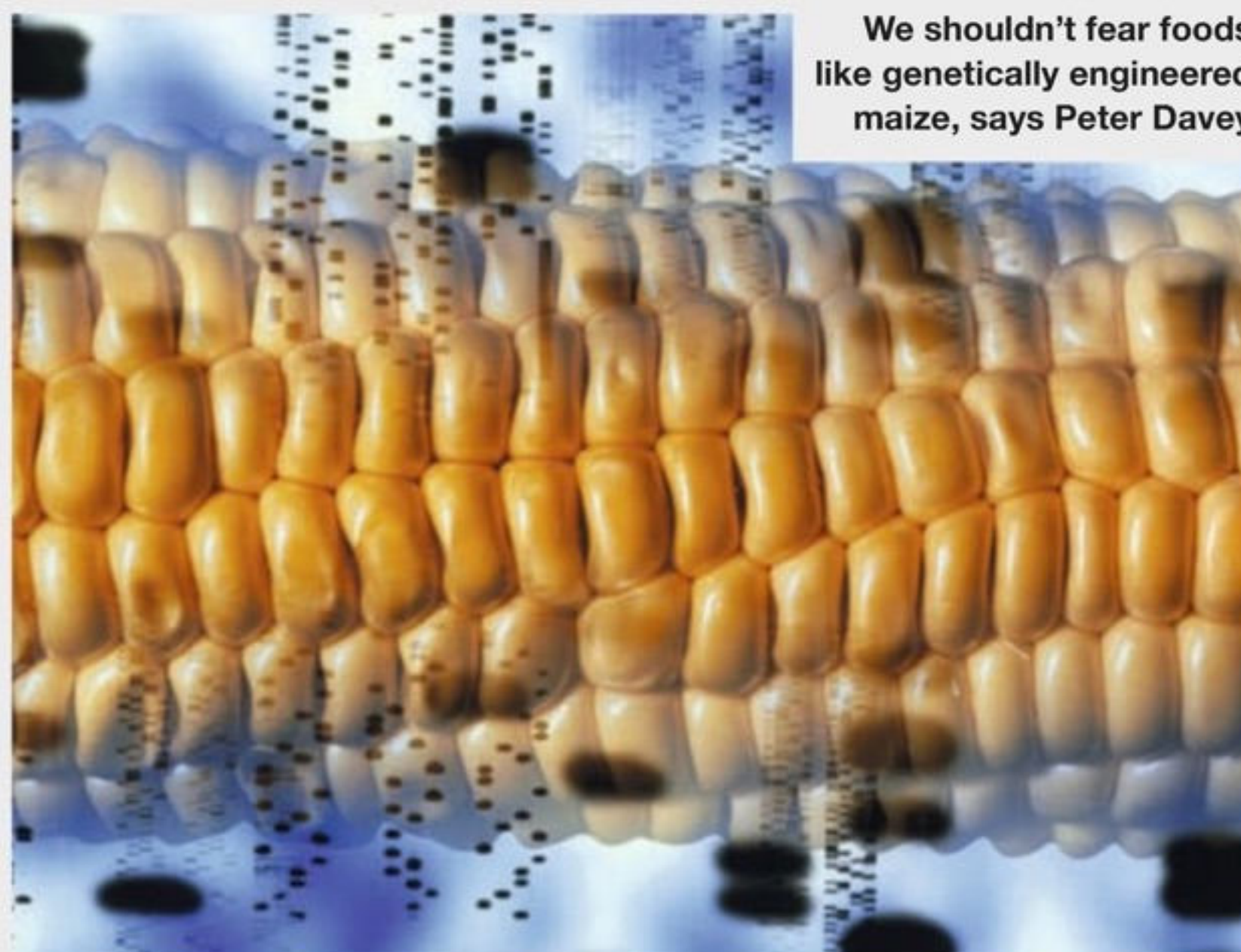


With regard to the 'Burning Question' on genetically modified potatoes and GM food in general (January, p25), those who refer to "Frankenfoods" should perhaps remind themselves that it is only in the film versions of Mary Shelley's work that the creature is portrayed as inarticulate and malevolent. The American scientist and writer Stephen Jay Gould, in an article on the subject, reminded his readers that the book reveals the creature to be intelligent and (originally) sympathetic.

This should serve as a warning, for those who rail against the horrors of tampering with the 'natural order of things', about the dangers of premature judgment. The late Arthur C Clarke pointed out that although we might like to think of farms as 'natural' and 'organic', they are actually machines, taking such simple constituents as air, water and soil and producing food from them. I'm afraid that many people consider that whatever happens to be around at the time as 'natural' and whatever is being introduced as 'unnatural', without thinking more deeply about the matter.

I believe that it was Jonathan Swift who wrote that the man who makes two blades of grass, or two ears of corn, grow where only one grew before deserves more of mankind than the whole tribe of politicians. I presume that the same thing applies to pigs.

Peter Davey, Bournemouth



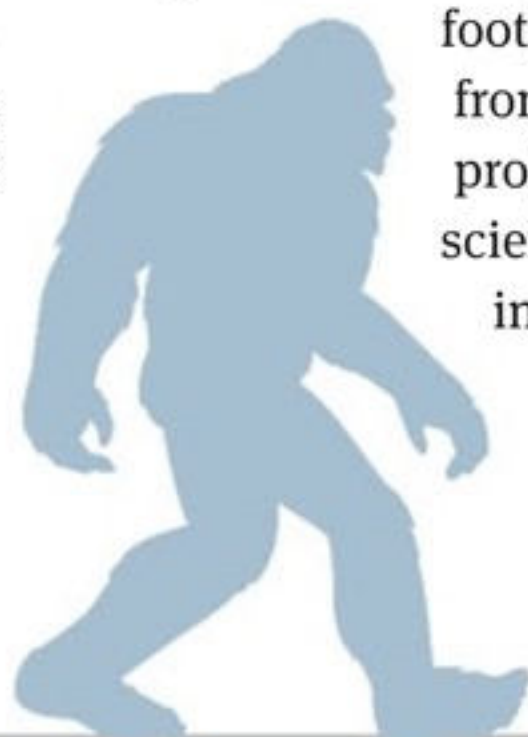
We shouldn't fear foods like genetically engineered maize, says Peter Davey

Nice quotes Peter! The same point was made in this year's Richard Dimbleby lecture, televised on BBC One, by the geneticist Sir Paul Nurse. He said "We need to consider what science has to say about the risks and benefits [of GM crops] uncoloured by commercial interests and ideological opinion." – Ed

Big, furry, fictional?



I was dismayed by your somewhat defeatist article, 'Should we give up looking for Bigfoot?' (March, p27). Should SETI give up looking for life in other parts of the Universe because they haven't found any signs? Should the Large Hadron Collider be shut down because they *have* found a certain particle? Are you seriously suggesting that just because the 'yeti finger' proved to be from a human, the yeti doesn't exist?



I hate to say it, but mainstream science will not carry out a proper investigation of Bigfoot, even though we have had over 200 years of evidence of its existence – footprints and eyewitness accounts as well as countless unidentified "animal calls".

Sceptics, of course, dismiss footprints as hoaxes. Apart from the North American Ape project, no establishment scientist will go near this investigation because they are terrified of what their peers may think. Should a new species of bipedal ape be discovered, it

would upset the accepted view of human evolution. Scientists should not be surprised to find other hominid-like creatures, and should in fact make a positive effort to look for them. But they would rather not!

James Cairns

I don't know, if they exist, how Bigfoot and the Loch Ness Monster elude us. But I hope they continue to do so, because if man finds them they will be (at best) trapped, caged and experimented upon. At worst, they will be killed, subjected to a postmortem and end up in jars in a museum. I, for one,

wouldn't tell anyone even if I knew where they were.

Jo Hammond

There is no way expeditions could have fully explored the hundreds of miles of mountains in the Himalayas. There is also no way they could've recorded even a small region for any amount of time. The yeti is still worth looking for. The Loch Ness Monster might not exist, considering the number of people who have looked for it. But as I am sure Dr Naish will agree, this does not rule out other sea serpents. Sometimes, even if someone is unscientific, you

WHAT DO YOU THINK?

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Studying the genetics of
Tasmanian devils may help
the species beat disease



have to admire their courage and curiosity, even if they are Bernard Heuvelmans.

Milo FS Morris

Personally, I prefer to admire people who are scientific! – Ed

Fuel cell fan



I was interested to read your recent article on local energy generation (February, p48), but was disappointed that there was no mention of the UK company AFC Energy, who are on the cusp of commercialising a low-cost fuel cell that will transform the chlor-alkali industry and maybe others.

Phil Taylor

The energy-intensive chlor-alkali industry produces sodium hydroxide for soap and electroplating, chlorine for cleaning products and hydrogen for much else. – Ed

Saving species



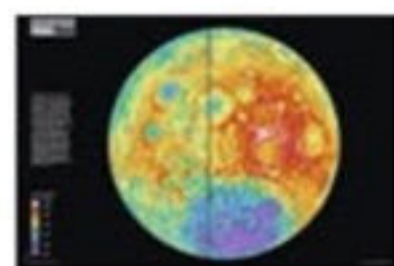
The March issue of Focus had an extremely well-written article on saving species by altering genetics. This informed me that such amazing things as preventing a Tasmanian devil from

getting cancer are now within our grasp. Would this sort of genetic alteration also be possible on a larger animal, such as something the size of a bear or lion?

Billy Burrows, Nottinghamshire

JV Chamary replies: *The size of an organism should have little influence on whether its genetic makeup could be modified to protect it from disease. What will make things tricky is whether the genetic control systems – those that dictate how genes are switched on/off – are complex. This means ‘simple’ organisms like bacteria are easier to genetically modify than, say, a bear, lion or Tasmanian devil.*

Moon walking



In your March issue, the ‘Mega Pixel’ picture of the Moon showed heights. As there is no sea level, what determines zero height?

Denise Surtees

Zero height on the Moon is taken as the mean radius from the centre – its value is 1,737.10km. – Ed

The high frontier

Further to your reply to Peter Davey’s letter (January, p28), the reason that space exploration is so

expensive is that an expendable converted ballistic missile is used. Having to build a new vehicle every time drives up cost. If fully reusable spaceplanes were built, single nations and even private companies could open up the high frontier. Reusability is the key!

E Philpott, Neston

I think you’ll find...

On page 80 of the March 2012 issue, you claim that the fastest official time to complete a marathon was 2:03:59. In fact the fastest official time is 2:03:38, by Patrick Makau of Kenya in 2011.

Paul Emecz

While reading issue 236 (December 2011), I noticed errors in the ‘Q&A’ Quickfire column on p81. The author says that “every element heavier than lead (element 82) is unstable”. I presume by ‘heavier’ elements he means a higher atomic number, in which case bismuth (element 83) is a stable metal.

Secondly, he says ‘the heavier they are, the shorter the half-life’. But there is no such direct correlation: for instance, thorium (element 90) has a long-lived isotope, Th 232, with a half-life 1.41×10^{10} years, while the previous elements (84-89) have shorter half-lives in all of their isotopes.

John Davidson, Wimborne

Luis Villazon replies: *It is true that the relationship between atomic weight and isotope stability isn’t exact – I was referring to a general relationship. Bismuth is regarded as stable because it has a half-life that’s a billion times longer than the current age of the Universe. That’s because it is only just heavier than lead, so it sits right on the boundary between stable and unstable.*

Oops... On p102 of the March issue, the Minecraft picture should have been credited: ‘Image by seriosbrad and Riyuzakisan of deviantArt.com’

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Sir Konstantin NOVOSELOV

The Nobel Prize-winning physicist talks to **JV Chamary** about graphene, the miracle material that could transform technology



“
*I try not to
use the term
'discovered'.
We observed
graphene*
”

I was rather technical from my early years.

As far back as I can remember, I was using our family kitchen for my little experiments when my parents were away – probably some electrolysis, melting stuff. I was trying to clean the kitchen before they came back, but obviously some marks were left.

I was always interested in how things work. When I was seven, I made my first electromagnet. I was quite impressed that, starting with very simple things – a battery, a piece of copper wire and a nail – you could get something that actually worked. The type of experiments I enjoyed the most were those where you start with something simple and get some fascinating results. And I guess graphene is a very bright example of it.

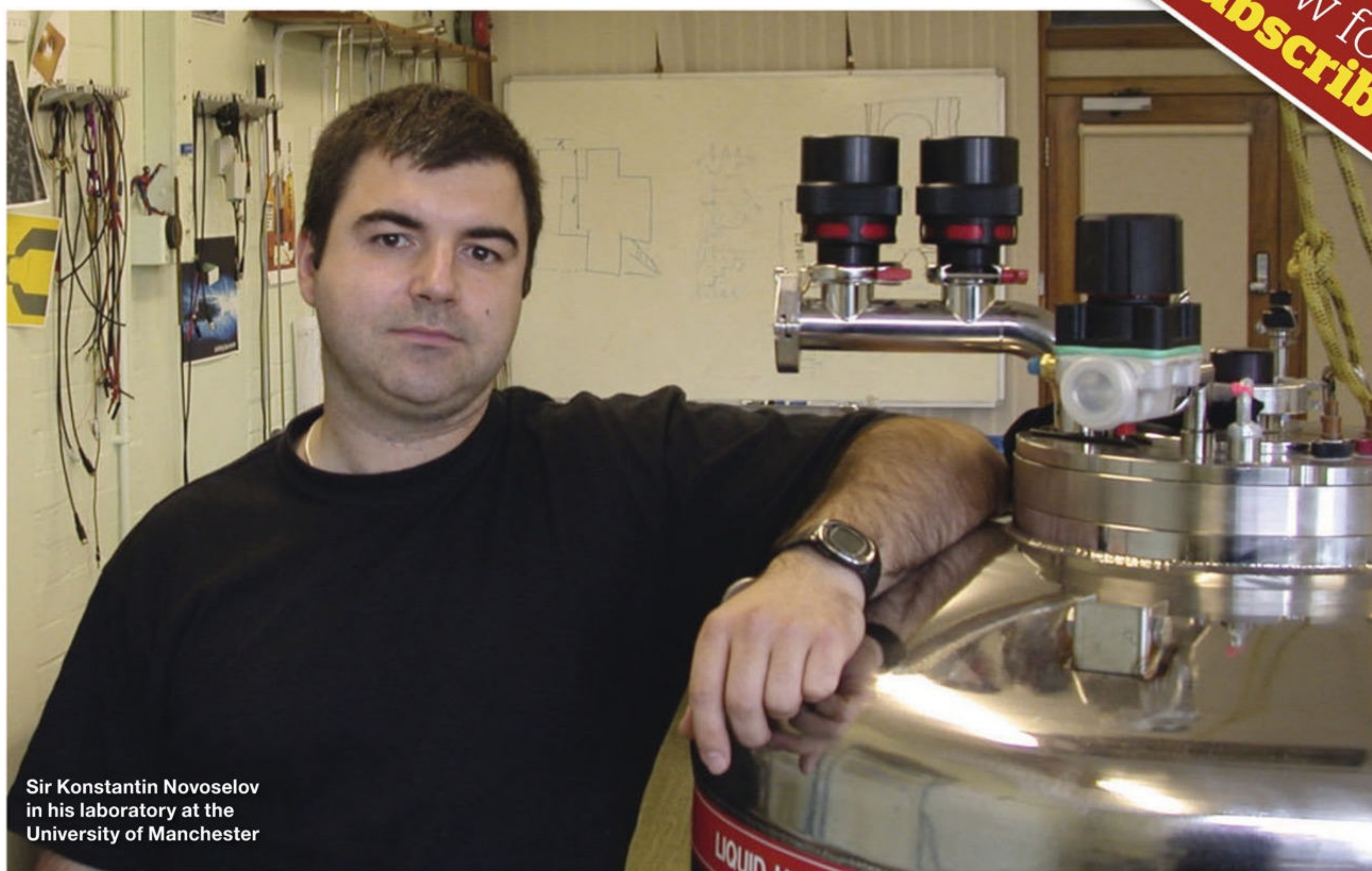
I followed in Andre Geim's footsteps over the years.

He graduated from the same university, the Moscow Institute of Physics and Technology, 15-20 years before I did, and then I worked in the same research institute – the Institute of Microelectronics Technology in Chernogolovka, near Moscow. [Novoselov and Geim won the 2010 Nobel Prize in Physics for their work on graphene.]

Andre had a reputation of being a very intelligent physicist. When he was looking for a PhD student and invited me to work with him, I didn't think twice before taking the opportunity. He was in Holland, in Radboud University Nijmegen. He moved to Manchester University and invited me to join him, and again I didn't think twice. He never casts too much of a shadow – it's probably impossible to beat him in generating ideas, but he always allows you to explore your own. For some time, I've had my own research agenda.

'Miracle material' is a good way to describe graphene.

Imagine the thinnest, strongest, most conductive, most thermally conductive, most permeable, most optically transparent material – that's graphene. It's a two-dimensional arrangement of carbon atoms. If you were to throw carbon atoms on a plate and



Sir Konstantin Novoselov
in his laboratory at the
University of Manchester

allow them to arrange themselves, they would form into hexagons, like chicken wire. If you can picture a single layer of this chicken wire made of carbon, that's graphene.

It's the extraordinary properties of carbon that make it special. I don't think nature chose carbon as the base for life for nothing. It has this property of making different chemical connections and changing those connections quite easily, and really it is this property of carbon atoms which makes graphene such a special material.

The possible uses for graphene come from its properties. If you have the strongest material, you probably want to use it as reinforcement for composite materials. If you have the most conductive material, you probably want to use it for transistors. If you have transparent material, you probably want to use it as a touchscreen or some kind of protective layer. And so on. Because it is only one atom thick, you can bend and fold it easily, so you can imagine computers which are bendable and foldable.

But probably the most interesting applications are not there yet. Most people are simply talking about replacing other materials with graphene. They look at replacing copper interconnects in integrated circuits, or replacing the indium tin oxide in liquid crystal displays. But it is also impermeable to gases, and you can put it in a window because it will not allow

any gas through. So with this material, we really have to think outside the box, and it challenges us in this sense.

I try not to use the term 'discovered'. We observed graphene. We started with graphite, similar stuff to what you find in a pencil. For some time there was an idea that there might be certain possible advantages of making metallic transistors, and graphite [multiple layers of graphene] would in principle be a good candidate for this.

To make it, we tried several methods. Really by accident, we came to the 'Scotch tape' method. You take a piece of graphite, put some Scotch tape on it and – because graphite is a layered material – it's quite easy to peel off a few layers. After a few months of hard work in terms of peeling, it led to our observation of graphene.

You're not judged by your title, you're judged by your work. It wasn't my prime goal, when I was first going into science, to get the title of PhD. I started to do my PhD back in Russia [in 1997]. I never finished, but I learned a lot in that lab. And I continued in Holland and learned many things under the supervision of Andre Geim. But again, when there was a chance to learn more in Manchester, I didn't think that I needed to finish my PhD, I just took the opportunity when it arose.

So the title itself is not something which you should cherish, it's the experience which

you get during the process that's important. [Novoselov was finally awarded a PhD from Radboud University Nijmegen, after having moved to Manchester in 2004].

You don't usually know that you're shortlisted for a Nobel Prize. But about four or five years ago, our media relations people in Manchester wrote to me, saying "I get plenty of requests from the media for your mobile phone number because they think you could be in line for a Nobel Prize this year."

And that was quite detrimental. For a week, you think, "Is it really true, could I really get it?" It was a bad week for me – after that I tried not to think at all about it, tried not to speak with anybody, tried not to read any news. Otherwise it can ruin your life.

So that's why, in 2010, it came as a complete surprise. I was on a Skype conversation with our collaborator in Holland, discussing some recent experiments. They phoned and said, "You have about 30 minutes of normal life left."

I became a British citizen quite some time ago. [Novoselov was knighted for services to science in 2012.] I enjoy living in Manchester in particular. Let's be honest, there are not that many things which you can like about Manchester! But it's so easy to communicate with people here, you feel that you are tuned to the same wavelength, and the sense of humour is there. ■

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GOOD TO

Lying, cheating and getting angry will help you get ahead in life. **Luis Villazon** reveals how science is showing that being bad can make you more successful

Humans are a social species – we need each other to survive. Civilisation is the end product of hundreds of generations of people working together to achieve more than what any of them could alone.

But our greatest threat is no longer the environment or other animals, it's our fellow man. As a result, we've evolved morality, law and the conventions of polite society as a brake on self-interest, because groups that behave nicely do better than groups that squabble.

At least that's what you might think. Now a growing body of research is beginning to show that being bad can actually be good – at least for individuals. Lying, boasting, cheating and losing your temper aren't simply successful strategies for the isolated renegade, they're actually positive traits that can make us stronger, more focused and creative, healthier and more popular.

The trick, of course, is knowing exactly when and where to unleash your dark side. So over the next seven pages, allow us to present the *Focus* guide to losing friends, alienating people... and coming up smelling of roses anyway. ►



BE BAD





WORK

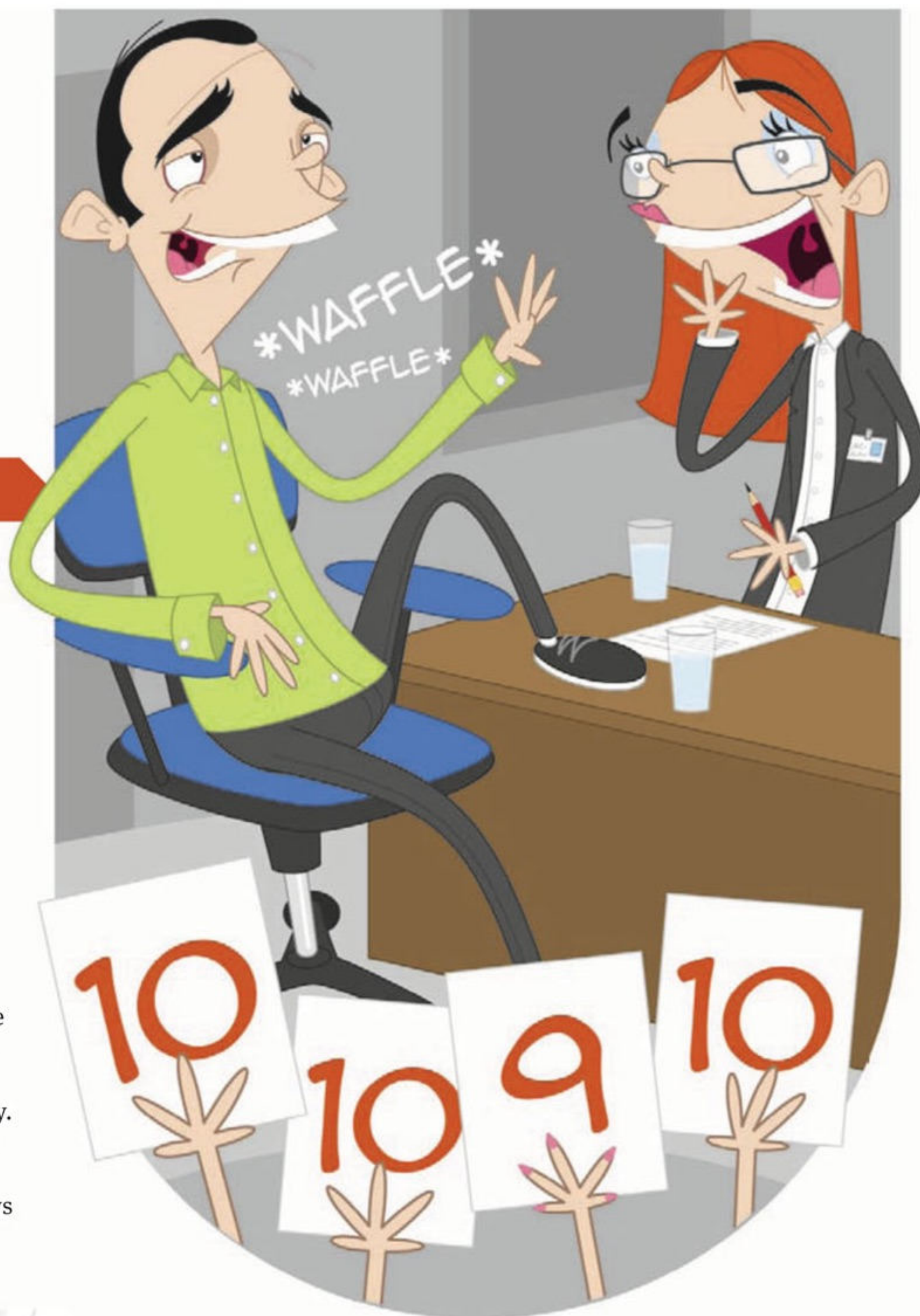
Dominance and dastardly deeds are key to climbing the career ladder

Clinch the job

In a crowded job market, landing that prime position is all about making a great first impression. But you might be surprised to discover what that first impression should be.

Dr Victoria Brescoll of Yale University showed test subjects one of two recorded job interviews in which the candidate talked about losing an important client at their previous job. Half the subjects were shown a video where the candidate behaved angrily and blamed his co-workers. The other subjects were shown a version where the candidate expressed sadness at the lost client. Taking responsibility for your mistakes might seem like the grown-up thing to do, but the angry candidate was actually rated as more competent than the sad one, and better able to cope with a position of high responsibility.

Men who are modest in interviews are also judged to be weak and less likeable than vain or arrogant candidates, according to a similar study by social psychologist Dr Corinne Moss-Racusin at Rutgers University in New Jersey. "Men are rewarded for their 'bad' behaviour because this falls in line with strict expectations for masculinity," she says. "In contrast, when they behave in more modest ways (especially at work, where their performance has serious consequences) they are actually penalised."



Maximise performance

Far from "blowing out the light of reason" as American philosopher Ralph Waldo Emerson once said, anger can actually improve your analytical reasoning. In 2007, psychologist Dr Wesley Moons of the University of California, Davis, showed that inducing anger in test subjects improved their ability to quickly and accurately sift through the evidence in a trial case, or identify sources of bias in a written article.

Misery is sometimes seen as a source of creativity for musicians, artists and writers. But fury may be a better place to go. "I found that anger gives people a creative boost,"

says Dr Matthijs Baas of the University of Amsterdam, who studies the effect of mood on creativity. "But the advantage didn't last for long – anger is a taxing emotion to have."

And it's not just anger that can help you think: habitual liars and cheats have 22 per cent more prefrontal white matter in their brains and 14 per cent less prefrontal grey matter. Grey matter provides the moral restraint that stops us from lying all the time. But the extra white matter that liars have gives them superior language processing skills. That's because lying requires a lot of extra effort to maintain a plausible fantasy.



Rise to the top

! Men who self-identify as disagreeable and aggressive earn 18 per cent more than those who think of themselves as 'nice', says Timothy Judge, a professor of management at the University of Notre Dame in Indiana. "Agreeable people are better liked [but] earn less and rise to lower positions." Women who called themselves disagreeable earned about five per cent more than their friendlier colleagues.

! Think your boss is a psycho? It could be true: four per cent of managers are psychopaths, exhibiting traits such as ruthlessness

and a lack of empathy. "There are occupations in which behaviour considered 'bad' may be productive," says psychology professor Robert Hare. Those with psychopathic characteristics rise quickly up the ladder. Managers are four times more likely to be psychos than the rest of us.

! Benjamin Franklin said, "Early to bed, early to rise, makes a man healthy, wealthy and wise." But a 2005 study at Harvard University found that late risers earned just as much as early ones – they just drank less coffee. So much for the Protestant work ethic.



Closing the deal

When you're negotiating a deal, being rude and losing your temper is sometimes the best move you can make. Hajo Adam, an expert in organisational behaviour at Northwestern University in Illinois, asked volunteers to try and sell mobile phone contracts over a computer chat interface. The volunteers thought they were negotiating with another human, but the responses were actually supplied randomly by a computer program.

When the program sounded angry, saying things like "I'm going to offer \$115, because this negotiation p*sses me off", then the human volunteers were more likely to concede negotiating ground and offer more favourable terms than when the computer used statements such as "This deal is going pretty well so far, I think I'll offer \$115."

This tactic doesn't work everywhere, cautions Dr Adam. "For anger to have these positive effects, it needs to be used sporadically, targeted carefully and expressed appropriately." Losing your temper is also perceived differently in different parts of the world: Western business culture interprets anger as an expression of toughness and resolve, whereas in Asia it's seen as a loss of control.



RELATIONSHIPS

Lying, cheating and mild violence are the secret to a successful social life

Bad boys get the girl

Narcissism, psychopathic traits and Machiavellianism are known as the 'Dark Triad' by psychologists. Being selfish, vain, impulsive, manipulative and a liar might not sound appealing, yet Peter Jonason of New Mexico State University found that people who scored highly for these traits had more success finding sexual partners than their nicer rivals. Both men and women with Dark Triad personalities did better, but men saw the biggest advantage.

"Bad boys are not luckier in love – they are luckier in sex. They are better suited to get women to sleep with them," explains Prof Jonason. "But they do not have the 'right stuff' for long-term relationships and, by extension, love."

Dark Triad men seek admiration, attention and status, and are spontaneous and irresponsible. This drives them toward a 'hit and run' strategy when finding partners. Although this is unlikely to lead to a lasting relationship, Dark Triad types feel less guilt about hurting others and simply move on to the next conquest.



Lying children are smarter

Parents often tell their kids "The most important thing is to tell me the truth." While we value honesty in our children partly as a way of maintaining control over them, we also see honesty as a valuable trait for adulthood, and hope to encourage honesty early on so our kids grow up to be successful members of society.

But Kang Lee, director of the Institute of Child Study at Toronto University, found that children who start telling lies at an early age have brains that are better at cognitive processes such as problem solving and verbal reasoning. "Children must be able to recognise different social

situations and act accordingly," says Dr Lee. "Also, they must inhibit the truth and come up with a convincing lie. All these require high-level cognitive abilities. There are therefore significant correlations between children's cognitive abilities and lying."

By the age of 12 almost every child lies, according to Lee's research. But, at age two, just 20 per cent of children can lie, and those kids are likely to grow up to be higher-achieving adults. This isn't because they're deceitful fraudsters – there's no link between lying and cheating in exams, for example. It's simply because their brains are more capable and creative.

Labours of love

! 'Forgive and forget' may sound loving, but it doesn't get results. When newlyweds forgave their partner's bad behaviour, they were much more likely to be presented with a repeat performance, compared to when they stayed angry. According to Dr James McNulty of the University of Tennessee, forgiveness often resulted in diminished respect.

! Older men chasing younger women improves the longevity of the species. Biologist Dr Shripad Tuljapurkar of Stanford University argues that men pursuing younger women are driving up the lifespan of humans as a whole, by spreading their genes well after the rest of us have given up.

! Keeping it in the family isn't such a bad idea after all. Dr Kári Stefánsson, founder of deCODE Genetics in Reykjavík, looked at the family trees for everyone in Iceland and found that marriages between third cousins resulted in more children than those between completely unrelated couples.

! The act of spanking brings couples together, according to social psychologist Dr Brad Sagarin of Northern Illinois University. He studied the hormone levels of participants during S&M activity and found that the couples' elevated testosterone and cortisol levels translated into increased closeness in their relationships.



Break a few plates

What's the secret to a long-lasting relationship? Tolerance? An even temperament? Not according to Ernest Harburg, a professor of psychology and epidemiology at the University of Michigan, who followed 192 couples over 17 years and tracked whether each spouse expressed or suppressed their anger during disagreements.

Couples in which both partners buried their anger had a 50 per cent chance of one or both of them dying during the study period, according to Harburg's research. Where at least one partner expressed anger, the death rate was only 25 per cent. Losing your temper, it seems, can improve your longevity.

Part of the reason for this may be that habitually suppressing your anger increases the chance that you'll become violent when drunk. Jens Skogen of the University of Bergen measured the relationship between drinking and violence among 3,000 young people in Norway.

Among those who normally suppressed their anger, a 10 per cent increase in drinking was associated with a five per cent increase in violence. For those used to expressing their angry feelings, increased drinking showed no corresponding increase in violence.

Alcohol lowers inhibitions and if you normally keep a lot of anger bottled up, a heavy drinking session may be all that is needed for it to spill out into violence.



HEALTH

Naughty thoughts and a little alcohol keep your body and brain in good shape

Boozing benefits

Alcohol is bad for you. According to clinical psychologist Dr Charles Holahan of the University of Texas at Austin, heavy drinkers have a 45 per cent higher mortality risk than moderate drinkers. But it seems *not* drinking is even more dangerous. In the same study, Holahan found that teetotallers had a 51 per cent higher mortality risk than moderate drinkers. This suggests that you're six per cent more likely to die young if you don't drink at all than if you drink heavily.

People who describe themselves as teetotal in studies are often recovering alcoholics, who may have already damaged their long-term health through drink. But the Holohan

study adjusted for previous problem drinking, existing health problems, social status and gender. Total abstinence still came out as worse than heavy drinking, and much worse than moderate drinking.

Jens Skogen of Bergen University compared 38,000 Norwegians and found that non-drinkers were more likely to suffer from depression or anxiety than moderate or heavy drinkers. It's not the abstinence itself that's dangerous, he suggests, "But in societies where consumption of alcohol is the norm, abstinence might be associated with being socially marginalised and at increased risk of mental disorders."



Think negative

The human brain is a tangled web of connections. As we think about things, the activity of neurones spreads through this network to other related concepts. The strange thing is that sometimes, darker thoughts can prime our brains for more positive mental states.

GREED Volunteers given a stack of money to count felt less pain when they plunged their hands into hot water than those who counted blank pieces of paper. "Desire for money can diminish the perception of pain," explains Dr Kathleen Vohs, an expert in consumer psychology at the University of Minnesota.

LUST Thinking about casual sex improves your analytical skills. Lust focuses your attention on the here and now, improving your ability to concentrate on details, says Prof Jens Forster, head of the social cognition lab at the University of Amsterdam.

EVIL Kurt Gray of Maryland Mind, Perception and Morality Lab found that volunteers can hold weights for longer if they imagine doing a good deed – and longer still if they think of a bad one, like harming someone else. The effect, he says, is due to us thinking of 'baddies' as powerful. "When we think of ourselves doing evil, we become more physically tenacious." ■

Luis Villazon is a *Focus* Q&A expert



**MANY ROADS LEAD
TO THE MEDAL,
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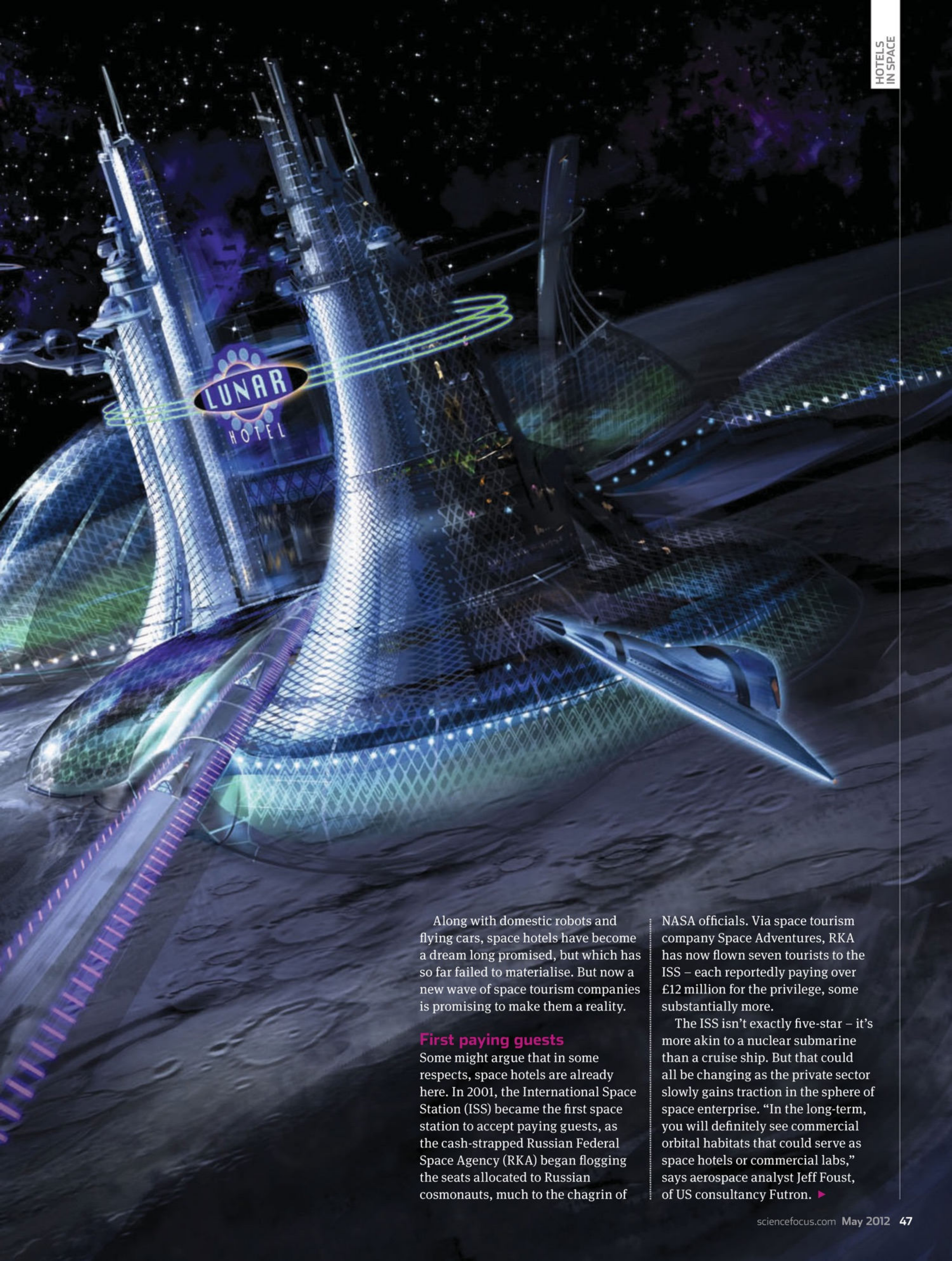
It has been long promised by entrepreneurs and science-fiction. But when will we be able to spend our first holiday in space? **Paul Parsons** finds out.

What a beautiful sunrise – probably the best one today. You’ve seen five so far. A crescent of light gradually brightens until the Sun bursts up into the blackness, sending a wave of colour tearing across the face of the planet 400km (250 miles) below, picking out familiar landmasses as well as vast swirling weather systems.

You’re watching from the comfort of a space hotel, an orbital tourist destination that circles the Earth once every 90 minutes. When you’re not taking in the incredible views, there’s the opportunity to try your hand at astronomy under the clearest

sky you’ll ever find, and for the truly intrepid, the chance to experience the outer limits rather more directly with a spacewalk.

Exactly 45 years ago Barron Hilton, then the president of Hilton Hotels, delivered a speech to an American Astronautical Society conference in Dallas outlining his vision of a Hilton hotel in orbit, to be followed later by one on the Moon. “If the world powers continue to restrict outer space to peaceful pursuits,” he told delegates, “there will be travellers in outer space – and where there are travellers there must be Hiltons.”



Along with domestic robots and flying cars, space hotels have become a dream long promised, but which has so far failed to materialise. But now a new wave of space tourism companies is promising to make them a reality.

First paying guests

Some might argue that in some respects, space hotels are already here. In 2001, the International Space Station (ISS) became the first space station to accept paying guests, as the cash-strapped Russian Federal Space Agency (RKA) began flogging the seats allocated to Russian cosmonauts, much to the chagrin of

NASA officials. Via space tourism company Space Adventures, RKA has now flown seven tourists to the ISS – each reportedly paying over £12 million for the privilege, some substantially more.

The ISS isn't exactly five-star – it's more akin to a nuclear submarine than a cruise ship. But that could all be changing as the private sector slowly gains traction in the sphere of space enterprise. "In the long-term, you will definitely see commercial orbital habitats that could serve as space hotels or commercial labs," says aerospace analyst Jeff Foust, of US consultancy Futron. ►

► In 2010, Russian firm Orbital Technologies made headlines with its elaborate plans for a four-room space hotel, the Commercial Space Station (CSS), that it hopes to open in 2016. "The hotel will be aimed at wealthy individuals and people working for companies who want to do research in space," said Sergei Kostenko, chief executive of Orbital and a former cosmonaut. "A hotel should be comfortable, and this one will be."

The structures won't just need to be lavish, they will also have to stand up to the rigours of outer space. When you're travelling at 8km/s, even tiny specs of grit and dust, known as 'micrometeorites', present a significant hazard. The International Space Station incorporates layers of armour to guard against this. The other big danger is radiation. Earth is

shrouded by both an atmosphere and its natural magnetic field, which serve to soak up much of the harmful high-energy particles that get belched out by the Sun and other powerful sources across the Galaxy.

One space hotel company, Barcelona-based Galactic Suite, has come up with a solution to these problems: acquiring tried and tested technology developed for the ISS. The ATV (short for Automated Transfer Vehicle) is an expendable cargo craft built by aerospace firm EADS Astrium for the European Space Agency to run supply missions to the orbiting outpost. Prior to the global financial crisis, ESA began work adapting the ATV as a crewed vehicle – with all the life support systems and radiation shielding required. Galactic Suite has now taken this technology and

"You will see commercial orbital habitats that could serve as space hotels"



incorporated it into a modular design for a commercial space hotel – with each module essentially consisting of an ATV. It hopes to launch the first module in 2014.

This approach of drawing upon experience has also been adopted by Orbital Technologies. It has partnered with Russian spacecraft manufacturer RSC Energia, which has built practically all of the hardware for the Russian space programme, from the Sputniks to the mighty Soyuz rocket. Crucially, the company also designed the Salyut space stations of the 1970s and the Russian parts of the International Space Station (ISS).

"We are using reliable, space-certified elements in order to accelerate the schedule, reduce the risks and optimise the performance of the CSS," says Orbital spokeswoman Stacey Tearne. The CSS will be placed into Earth orbit within 100km (60 miles) of the ISS. If an emergency were to occur on the CSS, it would be feasible to evacuate guests across to its orbital neighbour – and vice versa.

Are we there yet?

A big stumbling block holding up the development of private space hotels is the lack of a commercially operated spacecraft capable of taking tourists to Earth orbit. Virgin Galactic, the most high profile of the companies planning to offer tourist flights into space, is making great strides – it hopes to test fly its first spacecraft beyond Earth's atmosphere later this year. Passengers could take their first rides in 2013 or 2014. But Virgin is only planning to operate suborbital flights at present. The fastest a Virgin spacecraft needs to travel in order to do this is Mach 3. Getting to orbit requires accelerating up to Mach 25.

It's the transport issue that makes Orbital Technology the front-runner in the race to open the first working space hotel – it already has its ticket to space sorted. Guests and staff will blast off from Earth using existing technology – Energia's Soyuz rocket, a design that has been delivering ►

ORBITAL ACCOMMODATION

Each company will offer a different experience – and the price tags vary somewhat, too

SPACE ADVENTURES

THE TRIP

The company sells short stays aboard the Earth-orbiting International Space Station. Guests are transported aboard a Russian Soyuz rocket. All tourists are required to undergo six months of rigorous cosmonaut training at Russia's Star City before flying.

HOW MUCH?

Cost is currently thought to be \$40–\$50 million (£25m to £30m) for 7–10 days in space.

WHEN?

Space Adventures is operating now – seven guests have flown.

ORBITAL TECHNOLOGIES

THE TRIP

With four rooms, the station will be able to hold seven passengers at any time. It will be available as a space hotel for tourists, as well as a private research platform for scientific organisations. No statement has yet been made about the pre-flight training requirements.

HOW MUCH?

\$950,000 (£600,000) gets you a return flight and a five-day stay.

WHEN?

Projected opening date is 2016.

BIGELOW AEROSPACE

THE TRIP

Founded by US motel king Robert Bigelow, this company has already deployed two test habitats in space. Its inflatable space station, the BA 330, will accommodate six people. Several BA 330s could be combined together to create an even larger orbital complex.

HOW MUCH?

No mini-breaks here – \$23 million (£14 million) buys you a 30-day experience in space.

WHEN?

Timescale unknown.

GALACTIC SUITE

THE TRIP

This aerospace design company based in Barcelona, Spain, wants to build a modular space station known as the Galactic Suite Space Resort. The company says the high speed of the module means it would orbit Earth every 90 minutes, and provide views of 16 sunrises a day.

HOW MUCH?

An estimated \$4 million for a three-day stay.

WHEN?

Current plans centre around the launch of a modified ATV module in 2014.

A DAY ABOARD A SPACE HOTEL



There will be no time to get bored when you're in orbit...

8.45 AM

Get up. In space the time zone is arbitrary, though Coordinated Universal Time (UTC) is a likely choice: it's the time kept on the International Space Station. Conveniently for Brits, it's the same as Greenwich Mean Time.

9.00 AM

Get washed. In the absence of gravity, the simple morning shower becomes somewhat less straightforward. The cubicles used on the ISS are sealed units with a suction device to remove water. Space hotels would use similar technology.

9.30 AM

Breakfast. Gourmet food is prepared on the ground, then dehydrated or vacuum-sealed for transport. The space hotel kitchen just reconstitutes and reheats it. Bungee straps and Velcro keep weightless utensils on the table.

10.00 AM

You spend the morning watching the world go by – literally. From its inclined orbit, the hotel covers a range of latitudes while the planet spins beneath. You watch from the observation deck without seeing the same place twice.

2.00 PM

Experience space first-hand by donning a space suit and stepping out into the void. Galactic Suite has said it will offer spacewalks from its space hotel – however for safety reasons these will be brief, maybe just a few minutes.

7.30 PM

Upload pictures of your day to Facebook, so your friends and family can see what you've been up to. Just as happens aboard the ISS, it's likely the tourists will be provided with remote access to a computer back on Earth.

10.00 PM

Sleep. Lying down is tricky when the lack of gravity means there is no 'down'. Floating free also leads to rude awakenings as you bump into the cabin bulkheads. The solution is a sleeping bag Velcro'd to the wall.



Q&A: BARRON HILTON

The 84-year-old former chairman, president and chief executive officer of Hilton Hotels looks at today's prospects of a hotel being built in space

Do you still think hotel chains will ultimately have branches in space?

BH Whether on Earth, or in space, a hotel should not be built unless there is a proven need for it. As I said back in 1967, a space hotel will become a reality only when it is financially practical.

Where would these space hotels be – in orbit, on the surface of the Moon, or on some other planet?

BH Wherever people travel, there will be hotels to accommodate their needs. Today, more than 40 years after the first lunar landing, and 30 years after the Space Shuttle first flew, private ventures are being put together as we speak. Sir Richard Branson is collaborating with design genius Burt Rutan to create a space tourism industry. The first step will be a suborbital trip into the weightlessness of space aboard Virgin Galactic's

SpaceShipTwo, from New Mexico's new Spaceport America.

Life aboard a space station orbiting the Earth would seem to be the logical next step to me. Obviously, life support systems would be the first priority, and only after that became foolproof would anyone focus on amenities to make travellers' time in space comfortable. From there, we're only limited by our imagination.

What would people do when they were up there?

BH If it were me, I'd be glued to the porthole, or even better, be looking out over the controls in the cockpit. If hotels were my vocation, then flying has been my avocation. I'm afraid I'm unlikely to go up into space myself, but I'm glad to see that visionaries like Branson and Rutan are helping forge a tourism industry in space. Just to experience weightlessness would be a thrill. Eventually, people will spend days at a time in space, either sightseeing and relaxing, or taking on more adventurous pursuits, like taking their own spacewalks.



Hilton Space Station 5 in 2001: *A Space Odyssey* – still just science fiction

Would the orbiting hotels maybe act as places to stop over before reaching your final holiday location on a planet?

BH That would seem to make the most sense. You have to be able to operate closer to home before venturing out into deep space. Water, oxygen, food and supplies would all have to be delivered or generated at a space station to accommodate space tourists.

How soon do you think we might see the first space hotels?

BH Back in 1967, I announced that

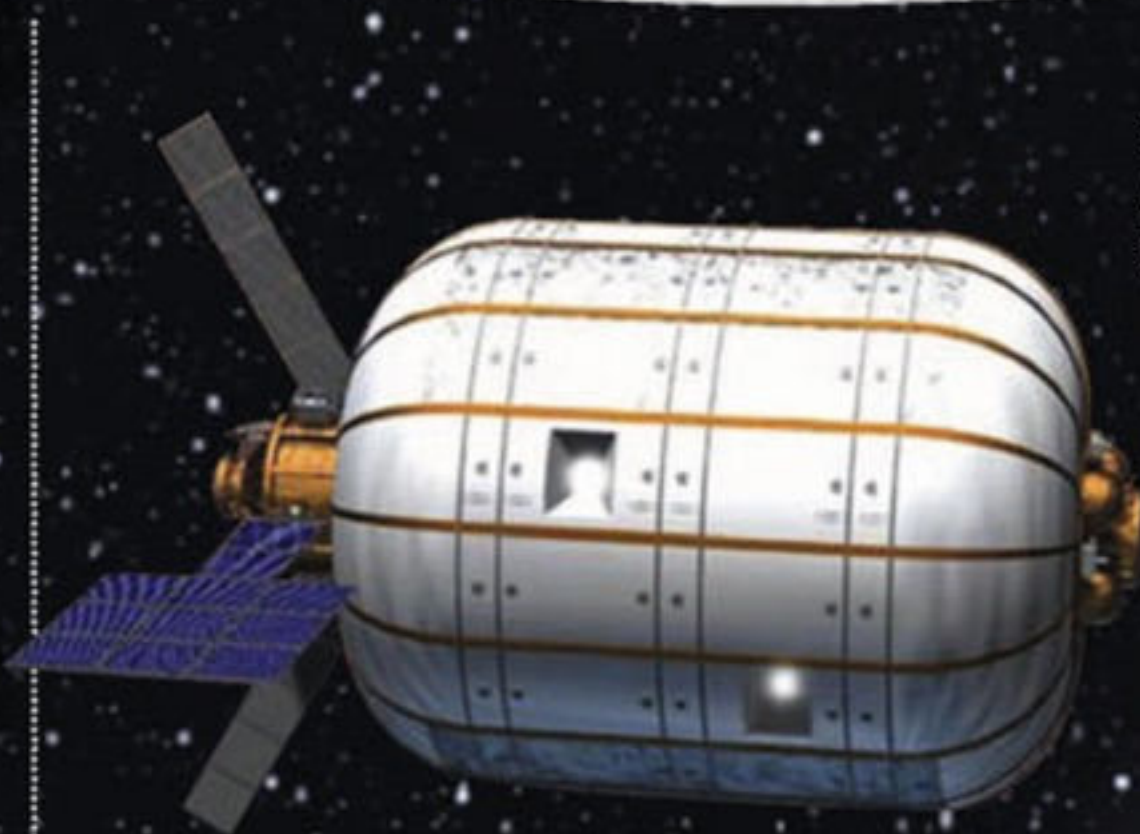
'Hilton Space Station Number Five' would be depicted that summer in a new motion picture called *2001: A Space Odyssey*. Twenty-three years later, Arnold Schwarzenegger checked into a Hilton on Mars in *Total Recall*. But so far, Hilton's presence in space has been the stuff of science fiction, rather than science fact.

► cosmonauts into orbit for over 40 years.

Others appear to be in a less strong position. In late 2011, US firm Bigelow Aerospace – which has advanced plans for inflatable space habitats – laid off half its staff, essentially putting its business plan on hold while the space transportation industry catches up.

Perhaps the most promising attempt so far to build a commercial, human-rated, reusable orbital rocket is the Falcon 9, currently under development by California-based aerospace company SpaceX. It has now completed two unmanned flights into orbit and expects to have its first manned test flight in 2014.

All things considered, analyst Jeff Foust thinks it is reasonable to expect the first basic space hotels to be open soon. "It's entirely possible the first one could be available in a decade or so," he says. Prices will initially be steep – tens of millions of dollars for a short stay – but, as with any new technology, economies of scale will gradually bring this down.



Bigelow Aerospace's BA 330 station

Once orbital hotels have been built, where next? In his 1967 speech, Barron Hilton alluded to the possibility of hotels on the Moon, while bases even further afield – such as on Mars and nearby asteroids – are being seriously considered by NASA.

On Earth, we're now free to holiday everywhere from Antarctica to the Sahara. The lesson from history seems to be that wherever the pioneers go, commerce soon follows. Why should space be any different?

"The first space hotel could be available in a decade or so"



"A short stop-over at our station will be the perfect beginning for a manned circumlunar flight," says Kostenko at Orbital. "Deep space manned exploration missions planned in the next decade are also welcome to use the CSS as a waypoint and supply station."

Indeed, as the science-fiction author Robert Heinlein once put it: "Get to low Earth orbit and you're halfway to anywhere in the Solar System." ■

Dr Paul Parsons is the author of Science In 100 Key Breakthroughs

FIND OUT MORE

Space Tourism: Adventures In Earth Orbit And Beyond
Michel van Pelt (Springer, 2005)

<http://bit.ly/spaceadventures>
Video from Space Adventures showing the space tourism experience

<http://bbc.in/spacetourismreality>
BBC Radio 4 programme *You And Yours* on space tourism

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Leonardo da Vinci ANATOMY OF A GENIUS

The largest ever exhibition of Leonardo da Vinci's studies of the body opens soon at Buckingham Palace. **Michael Mosley** was given a sneak preview



Michael Mosley trained as a doctor before becoming a BBC presenter and producer

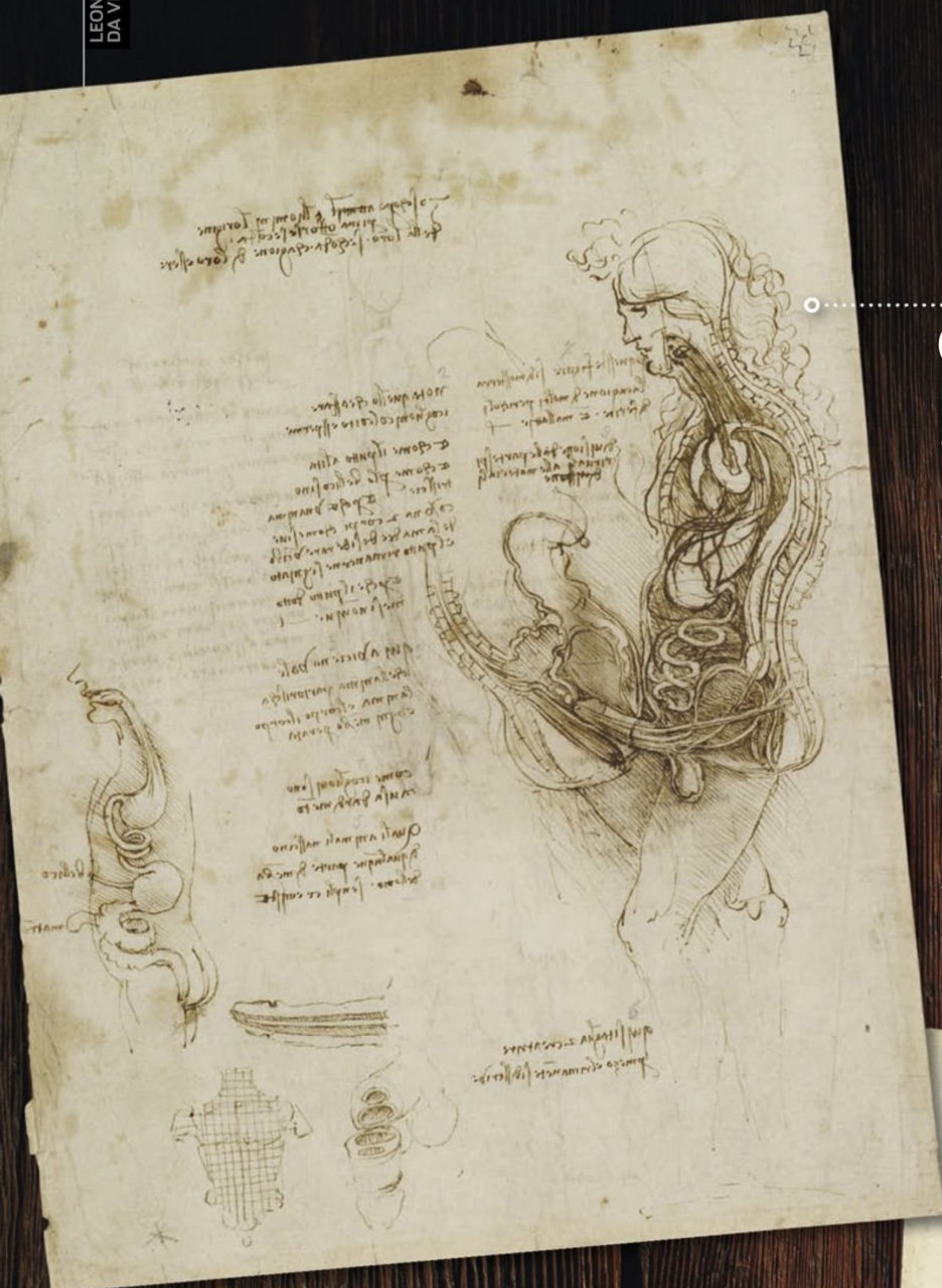


Leonardo da Vinci has long been recognised as one of the great artists, but he was also a pioneer in understanding human anatomy. Taking a scientific approach, he used his own techniques to explore the body and the way it worked. Leonardo dissected about 30 male and female corpses, using his powers of observation to understand function from form. He experimented too, making a glass model of the heart to study the flow of blood.

Leonardo intended to publish his studies in a treatise on anatomy. It would undoubtedly have transformed knowledge of the workings of the human body back in the 16th century. But when he died in 1519, his drawings

were a mass of disorganised material and were effectively lost to the world for almost 400 years. It wasn't until the turn of the 20th century that copies of Leonardo's anatomical drawings were published, too late to transform the course of medicine.

Today, 600 of da Vinci's drawings are owned by the British Royal Family, and are kept in a carefully controlled environment in the Print Room at Windsor Castle. On 4 May, many of them will go on display at The Queen's Gallery, Buckingham Palace. Here we take a look at some of the fascinating anatomical work in the Royal Collection, how it was created and how closely it resembles the human body as we understand it today. ►



Coitus captured

One of his earlier anatomical drawings, Leonardo started 'the Copulation' in around 1490. Above it he wrote: "I expose to men the origin of their first, and perhaps second, reason for existing."

It is an extraordinary image of the anatomy of sexual intercourse and extraordinarily inaccurate. That said, it was drawn at a time when he did not have access to human bodies. The woman is almost completely absent in this drawing and her spinal cord opens directly into her uterus. In the man there are three channels to the penis, one from the spinal column to transmit the 'animal' (soul), another from the heart transmitting a 'spiritual' element and a final channel from the testes, transmitting a 'material' element.

Ever since Leonardo created this drawing, anatomists have wanted to understand how the male and female genitals interact. We had to wait until 1999 for definitive images, when eight couples were recorded having sex in a magnetic resonance imaging machine in University Hospital Groningen in the Netherlands. One of the study's key findings: rather than the penis being straight during sex, as Leonardo envisioned, it is, as the authors describe, "the shape of a boomerang".

Skull schematics

To create this intricate drawing, Leonardo first sawed a skull in the median plane – creating right and left halves – before sawing off the front of the right side.

The drawing was done at a time when Leonardo was working in Milan for Ludovico il Moro, the Duke of Milan. He had got himself a job at Ludovico's court by writing a letter in which he claimed he could design and build all manner of ingenious machines and weapons. He added that he could also paint. He was employed, but paid less than the court dwarf.

What is striking about this image are the lines drawn that cut across the skull, almost like a scanner targeting a

deep-seated brain tumour. Here Leonardo is trying to plot the site of the '*senso comune*', the place in the brain which, according to beliefs of the time, housed the intellect. The point Leonardo identifies is actually the location of the pituitary gland, which we now know to secrete hormones. The home of general intelligence in the brain is still an active area of research, but it is now thought to be determined by a network of regions.

While Leonardo was wrong about the location of the intellect, he did appreciate that thought and inspiration reside in the brain, something that took other anatomists a surprisingly long time to accept.



Leonardo the scientist

To explore the world around him, the artist came up with ingenious techniques

Leonardo da Vinci was born in Vinci, Italy, in 1452. His father was a notary, while his mother came from a peasant family. Although he was an illegitimate child and received a limited formal education, Leonardo was in many ways lucky; he lived near Renaissance Florence – a place of wealth, artistic fervour, and opportunity.

As child and teenager he liked to walk in the hills and watch birds in flight. He had extraordinary powers of observation – his later studies of flight would remain unmatched until the invention of photography.

Leonardo the artist left us the *Mona Lisa* and *The Last Supper*. Leonardo the scientist drew in detail for the first time the workings of the human body. His techniques were ingenious. For example, to investigate how our eyes see he had to find a way to dissect them. In his notes, his technique reads like a recipe: “In order to study the interior without spilling its watery humour, place the whole eye in the white of an egg and boil until solid. Then slice both the egg and the eye transversely and you will find that no part of it will drain away.”

Time and time again, Leonardo tested his own ingenuity against the method and materials of his age. He designed machines to dredge and excavate huge tracts of land; he investigated new methods of agriculture and irrigation and a whole range of military machines. On one occasion, while climbing in the hills, Leonardo came across a cave and inside found the fossilised skeleton of a whale. From this he reasoned that the mountain must once have been under water and the Earth therefore must be far older than others imagined.

Indeed, throughout his life Leonardo appears to have been driven to explain the world around him, and to record everything he witnessed.

Heart of a woman

When Leonardo first started studying anatomy it was mainly so that he could understand the structure of muscles and their movement. But he soon became intrigued by what was going on a little deeper inside the body.

At the time Leonardo created this impressive drawing, circa 1509-10, public dissections were held – the dissection carried out by a prosector and the lesson read by the lector, the professor of anatomy. Although Leonardo probably attended these, he also did many dissections himself. Few of the bodies available, however, would have been female.

The kidneys and liver are in the right position, though the liver is too small. The heart consists of just two chambers – the ventricles, which pump blood to the lungs and the rest of the body. The strange structures Leonardo has drawn around the uterus are probably based on knowledge gleaned from dissecting cows.



Grasping the hand's physiology

These drawings (circa 1510-11) are another fine example of Leonardo's excellent work in understanding and depicting the workings of the human skeleton.

The two largest drawings show the palmer view, or palm side, of the hand (right) and the dorsal, or upper surface, (left) of the right hand. Below this are side views, with the thumb slightly lowered. Having completed these drawings, Leonardo states in his notes that he wishes to depict each individual bone in four aspects. A huge undertaking; as Leonardo correctly notes the human hand has 27 bones.

The drawings in the right margin show different structures coursing to the finger. He has picked out, among other things, the tendon of the *extensor digitorum*, which straightens the finger, and 'the vein that gives vital spirit to the finger' – the artery, in other words.

Muscular masterpiece

Leonardo's drawings of bone and muscle are quite simply superb and no-one before him had come anywhere close to achieving what he did. During the winter of 1510-11, he was working with Marcantonio della Torre, Professor of Anatomy at the University of Pavia in northern Italy, so he had better access to human material than at any other point in his career. The quality of his drawings reflects this.

Here Leonardo shows the shoulder in great detail from many different angles. Given the conditions of the time, few

would have been willing to do the gruesome work Leonardo carried out. Dissecting rooms were grim places. There was no way of preserving bodies, so within 48 hours there was a tremendous stench. The most important instrument an anatomist had were bare hands with long fingernails that were used to do a lot of the sharp dissecting.

Leonardo's plan was to create a set of drawings that could be used by surgeons. As he put it: "the human body will be unfolded to you just as though you had the natural man before you".



Wonders of the womb

Leonardo was fascinated by the strange and little-understood phenomenon of reproduction. He was particularly keen to understand the womb: "How a baby lives in it, the way it is enlivened and nourished... and what it is which pushes it out of the mother and for what reason it sometimes comes out of its mother's womb before due time."

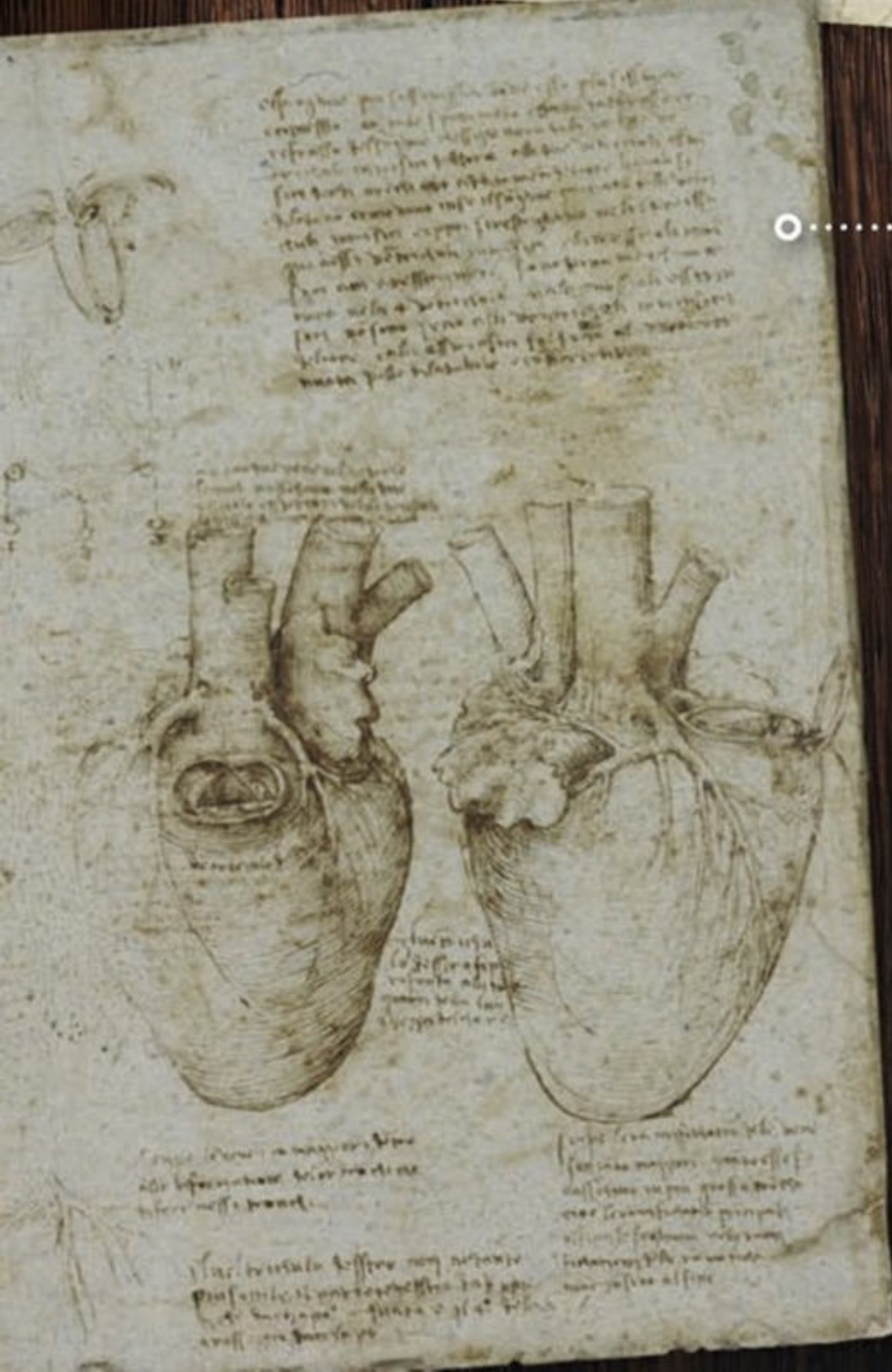
To create this, perhaps the best known of his anatomical drawings (circa 1511), Leonardo clearly had access to a well-developed foetus. Throughout his years of anatomical drawing, he aimed to be objective so colour is typically absent. But here, using chalk, he has given the foetus a reddish flesh colour, which makes it appear far more human and less like a purely anatomical study.

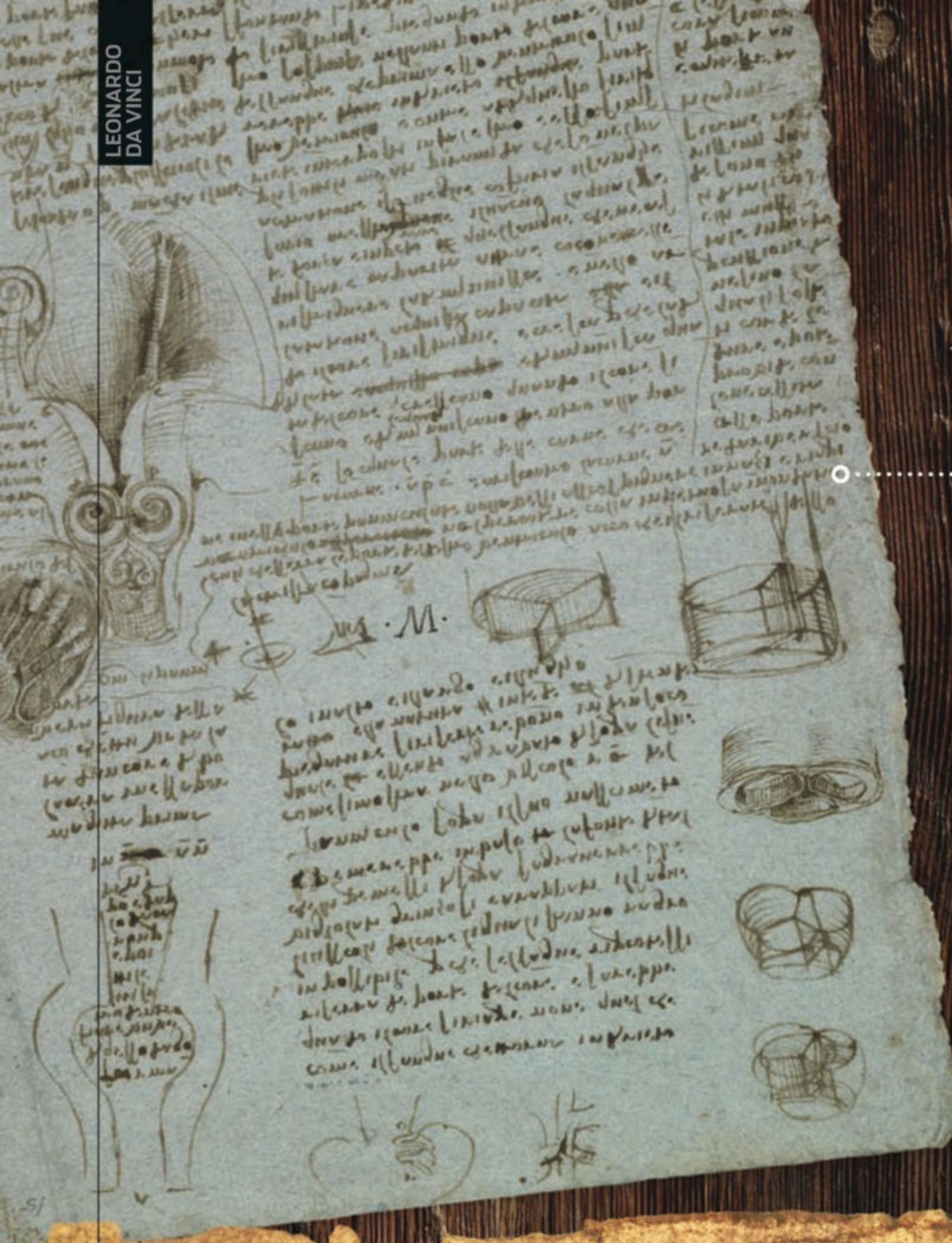
Leonardo is credited by many with being the first person to accurately place the foetus curled up in the right position inside a womb. But there are errors. The womb itself is rather curious and looks unlike anything you would find inside a woman. In the smaller drawings to the right, a great deal of attention is devoted to the different leaves of the placenta, but these are drawn from a cow. Each leaf acts as a small placenta. Leonardo never discovered that humans have a single large placenta.

Matters of the heart

Leonardo's investigations into the workings of the heart generated some of his most impressive work. Although he did, later in life, get his hands on human hearts he started off mainly by studying the hearts of oxen and pigs. Fortunately these animals are not that anatomically different from us. The drawings here (circa 1511-13) are of ox hearts.

His most famous observation, however, was based on a human. It was made after he had dissected an old man who died quietly in front of him. "I dissected him to see the cause of so sweet a death. This I found to be a fainting away through lack of blood to the artery which nourished the heart and the other parts below it, which I found dry, thin and withered." This is a clear description of coronary artery disease, the first in the history of medicine.





Turbulent ticker

Leonardo never realised that the blood circulates around the body, instead clinging to the belief, widely held at the time, that blood is made in the liver and consumed in the muscles. It was English physician William Harvey who would be the first to describe accurately how blood was pumped around the body by the heart, more than 100 years after Leonardo's death.

Of particular interest to Leonardo was the turbulence of blood in the heart and the impact this has on how the valves work. He was a skilled experimenter and created glass models of different parts of the heart to investigate turbulence. Using these models, he was able to prove that vortices are important for the opening and closing of the valves.

Some people believe it was Leonardo's failure to appreciate that blood circulates that meant he never completed his planned book on human anatomy. He seems to have realised that his studies were incomplete, perhaps flawed, and never attempted to publish.

Leonardo da Vinci: Anatomist will be at The Queen's Gallery, Buckingham Palace, from 4 May to 7 October. Visit www.royalcollection.org.uk to book tickets

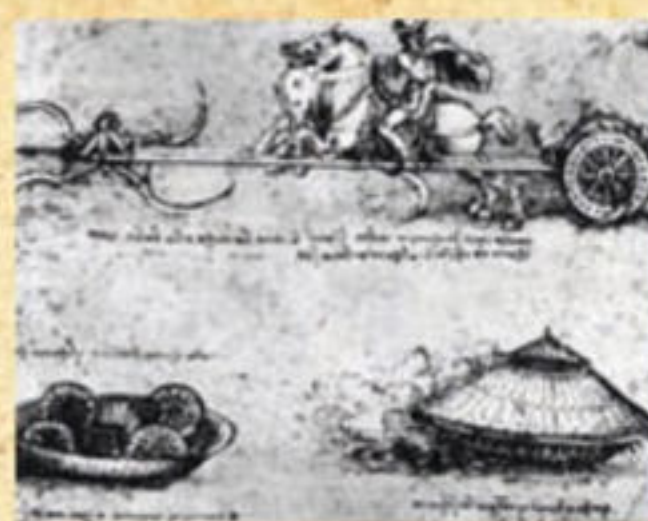
LEONARDO'S INVENTIONS

Just like his anatomical drawings, Leonardo's inventions lay unpublished in his notebooks. But his brilliant mind generated designs way ahead of their time



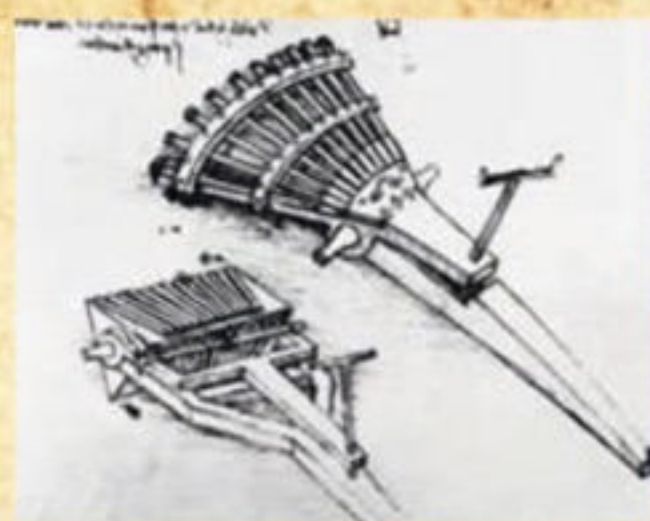
The first... robot

In 1495, before he began work on the *The Last Supper*, Leonardo designed and, it's been suggested, built the first humanoid robot. This armoured knight was designed to sit up, wave its arms and move its head via a flexible neck while opening and closing its anatomically correct jaw. Powered by springs, its movements could be predetermined by a mechanical programmable controller within its chest. It wasn't until 1954 that the first digitally operated, programmable robot, Unimate, was invented.



The first... tank

Leonardo's many military inventions included an armoured vehicle. Of these tanks, he said "One may hold bellows in them to spread terror among the horses of the enemy". For the BBC series *Leonardo - The Man Who Wanted to Know Everything*, we built a working tank and found a number of apparently deliberate design errors, added by Leonardo to prevent plagiarism. The first tank, the British Mark I, didn't see service until 1916. It had two naval guns rather than horse-frightening bellows.



The first... machine gun

Although unable to rapidly fire bullets out of a single barrel, Leonardo's machine gun was designed to fire volleys of gunfire rapidly. The idea was to mount 11 muskets side by side on a board and then place three of these on top of each other. While one set was fired, another would cool and the other would be reloaded. The Gatling gun, patented in 1861 by Richard Gatling and used in the American Civil War, was the first to offer controlled, sequential fire with automatic loading.



The first... diving gear

In 1500 Leonardo arrived in Venice just as the city came under attack from a Turkish fleet. He had a number of suggestions for repelling the fleet, including a diving suit in which someone could cut holes in enemy hulls. The suit was to be made of pig's leather with a mask and glass lenses. Cane hoses enabled the diver to breathe. The first diving suit was created by German mechanic Karl Heinrich Klingert in 1797. It had a leather jacket and trousers, and a metal helmet with a glass porthole.



The first... parachute

In 1485, Leonardo sketched a design for a parachute. He suggested what size it would need to be for a person to fall safely from a great height. It consisted of a pyramid-shaped frame draped with cloth. The parachute would, he said, enable someone to "throw himself down from any great height without suffering any injury". No-one knows whether he ever tested a full-scale model. The first successful parachute jump was made from a tower in France by Louis-Sébastien Lenormand, the creator of the modern parachute, in 1783.

Note to self...

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RESURRECTING THE MAMMOTH

As BBC documentary *Woolly Mammoth* showcases the Ice Age icon, **Henry Nicholls** investigates whether the long-extinct species could be brought back to life

EXIT



When *Jurassic Park* hit the big screen almost 20 years ago, Sergey Zimov had already set his sights on restoring a slice of the Siberian landscape to something of its former, prehistoric glory. At that stage, the Russian ecologist hadn't yet come up with a name for this ambitious project. Then he watched the movie. "The name Pleistocene Park came to my mind," says Zimov.

His small team of faithful followers have since worked tirelessly on this ring-fenced region just inside the Arctic Circle, attempting to turn it back to how it would have looked during the Pleistocene epoch. It's a vision that has seen the return of several charismatic herbivores,

including reindeer, musk oxen, bison and moose-like wapiti. There is, however, one notable absence: that most striking symbol of the last Ice Age, the woolly mammoth.

Ever since Michael Crichton's best-selling dinosaur fiction flew off the book shelves in 1990, there's been speculation that we might one day be able to reverse the extinction process. Sadly for dinosaur fans, DNA has a shelf-life in the thousands rather than the millions of years. But with the woolly mammoth relatively abundant up until around 15,000 years ago, and with plenty of specimens preserved in the sub-zero Siberian permafrost, the idea of resurrecting one may not be merely the stuff of fantasy. ►

► Until recently, it was widely assumed that freezing would damage cells irreparably, wrecking the nuclei and fragmenting the DNA within. But in late 2008, scientists at the RIKEN Centre for Developmental Biology in Kobe, Japan surprised the world by taking a mouse that had been stiff in a freezer for more than 15 years and using its cells to create a heart-beating, apparently normal rodent clone. This approach, they claimed, offered a chance to resurrect extinct animals or preserve endangered species with frozen tissues.

Though they didn't know it at the time, resurrection had already been achieved. Before the death of the last living Pyrenean Ibex (a species of wild goat) in 2000, scientists had had the presence of mind to harvest some skin cells and store them in the deep freeze. And in 2009, they revealed that they'd succeeded in cloning an Ibex, using a domestic goat to bring its genome back to life.

While the newborn Ibex didn't last long – dying from respiratory distress minutes later – the cloning was a triumph of human ingenuity. The researchers resisted speculating on whether their experiment improved the chances of resurrecting a mammoth, but elsewhere this was already a work in progress.

Mammoth meets mouse

The Museum of Mammoths in the Siberian city of Yakutsk is home to some of the best-preserved mammoth remains in the world. Pieces of skin, muscle and bone marrow have been sent to the Institute of Advanced Technology at Kinki University in Japan.

And in 2009, following the Ibex, geneticist Akira Iritani revealed what his team had been up to: they had managed to harvest cell nuclei from Yakutsk mammoth material and injected them into mouse eggs emptied of their own DNA. The mammoth genes didn't exactly leap to life, but it was still a surprise that they had got even that far.



Then last year, when researchers at the museum recovered a mammoth thighbone in even better nick, they got in touch with Iritani. "I have never seen a specimen in such good condition," says Dr Semyon Grigoriev, acting director of the museum. "It seems improbable that intact nuclei could remain, but our Japanese colleagues are very interested, especially in the bone marrow. Maybe they know something we don't."

Meanwhile, Russian and South Korean researchers – led by maverick cloning scientist Hwang Woo-suk – recently announced that they're also aiming to clone a mammoth, turning the animal's resurrection into a race. And if Akira Iritani's statements to the press are anything to go by, we can expect a healthy woolly mammoth within a matter of years.

Pasqualino Loi, a reproductive biologist at the University of Teramo in Italy, believes this is possible if intact mammoth nuclei can be found. "DNA is incredibly stable in particular conditions," says Professor Loi, who cites the recent news that seeds buried in the Siberian permafrost for 30,000

We can expect a healthy woolly mammoth within a matter of years

years still contained cells that could be used to bring the plant back to life.

Assuming that viable cells could be recovered, the first step would be to clone the mammoth's nuclei into the eggs of a common species, like the cow. The DNA-repairing capacity of the egg is simply incredible, says Loi.



Q&A: ALICE ROBERTS

Presenter of *Woolly Mammoth* on BBC TV



Alice Roberts tackled freezing conditions to film *Woolly Mammoth*

“A couple of rounds of cloning should fix damaged DNA.” If Iritani can get hold of some intact mammoth nuclei and is able to activate them inside the eggs of a readily available surrogate, he would ultimately want to transfer them to elephant eggs.

But to fertilise a female elephant you’d have to go to extraordinary lengths – quite literally. In most mammals, the entrance to the vagina is pretty easy to locate, just a short way into the urogenital canal. But the vagina of your average female elephant starts approximately 1.3 metres inside her body. And if you wanted to get anywhere near her egg-releasing ovaries, you’d have to navigate more than twice as far.

Remarkably, Thomas Hildebrandt, a biologist at the Leibniz Institute for Zoo and Wildlife Research in Berlin, has invented a piece of kit that will go the distance. He uses it to carry out artificial insemination of captive elephants, although he says it would be incredibly hard to use the same instrument to locate a newly ovulated egg – and you’d need some patience. “A female elephant ovulates on

average once every five years,” explains Dr Hildebrandt. ►



Palaeontologists examine one of the best preserved mammoth specimens

What is the show about?

AR The programme is specifically about woolly mammoths, a species that was ranging over the tundra of Eurasia for much of the Ice Age. The big question is why they died out – that’s one of the things we tackle in the programme, and you’ll meet scientists at the cutting edge of finding new knowledge about these ancient species. But there is a bit of adventure as well: we went up into the Arctic Circle in Siberia in search of the mammoths, and spent many months trying to track one down, which was frustrating and exciting.

Why study mammoths now?

AR It’s an exciting time because we’ve got more specimens coming to light, because the permafrost is melting much quicker than it has before. I met an amazing scientist called Dan Fisher, who realised that you had a diary of a mammoth’s life recorded in its tusks. People had identified bands of light and dark, like tree rings, inside the tusk. He stuck thin sections under the microscope and realised that, within those annual rings, you could actually count 365 smaller rings. You can then chemically analyse the tusks and see how mammoths moved through the landscape during their lives.

Was filming challenging?

AR The Arctic is an extreme environment for anybody. In spring it’s difficult to move around in the tundra, because it turns into a massive bog, so we had vehicles, Russian trains and boats, to navigate around this wetland environment. It’s quite warm – about 10°C during daytime – and 24-hour sunshine. We went back in the autumn, and that was just really cold. The most challenging aspect is probably for the cameramen and soundmen, who have to take their gloves off in order to operate their equipment. And at –40°C, you don’t want to be taking your gloves off for very long!

How does the CGI in the show compare to *Walking With Dinosaurs*?

AR In a way, dinosaurs are easier to animate because nobody’s ever seen one; although nobody’s ever seen a woolly mammoth, you kind of know how elephants move, so there’s something to compare them with. Having spent so long filming this past year, I felt quite close to mammoths in a strange way. Actually seeing a group of mammoths walking out across the Siberian tundra was really quite moving. You forget you’re looking at graphics, you think you’re looking through a window to the past and seeing these beasts again.

BACK TO LIFE

Could these animals be resurrected – and should they be?

DODO

In many ways, resurrecting the dodo bird is a more attractive proposition than resurrecting the mammoth. There's little question about the role that humans played in its extinction, and it would be far easier to incubate a cloned dodo in an artificial shell than to get an elephant to carry a mammoth clone. The dodo was adapted to life in the Indian Ocean, so there's no obvious reason why the bird would object to today's temperatures. And as the pre-eminent icon of extinction, the resurrection of the dodo should prove a good fundraiser. The drawback is that the warm Mauritian climate doesn't lend itself to DNA preservation, so the chance of finding an undamaged dodo nucleus is virtually nil.

Scientific plausibility: 1/5

Chance of ethical approval: 4/5



► Since successful cloning would require hundreds upon hundreds of elephant eggs, getting them from living elephants is out of the question. So the most practical option would be to take a sliver of ovarian tissue from a recently deceased female, then find a way to get it to release its eggs in the lab, on demand. This step itself poses some serious technical challenges, but none of them is insurmountable.

For most scientists, however, the popular interest in bringing back this behemoth is a distraction from a much broader evolutionary story. The fossil evidence indicates that the first mammoths appeared in Africa over five million years ago, only spreading into Europe and across Asia a few million years later. The most famous of its kind – and the most recent to evolve – was the woolly mammoth. This species emerged in the midst of the last Ice Age, around 700,000 years ago, in northeast Siberia, probably not that far from modern-day Yakutsk.

A genetic history

The woolly mammoth was also the first extinct species to have its entire genome sequenced – not with a view to bringing it back to life, but because of what it can tell us about mammoth biology. For example, changes in the gene pool of past populations can tell us a great deal about the prehistoric movements of mammoths. Genes can also reveal how mammoths differed from their elephantine relatives.

Take mammoth haemoglobin, the blood protein that transports oxygen around the body. When researchers reconstructed this protein in the lab, they found it behaved differently from elephant haemoglobin, releasing its oxygen at much lower temperatures. Such exquisite adaptation for survival in a harsh environment dominated by ice may have been the mammoth's downfall. As the last Ice Age began to warm, this cold-adapted creature would have found life much harder.

“The original huge, unbroken range of the species in its heyday shrank and became fragmented in ways that



SABRE-TOOTHED CAT

The La Brea tar pits in Los Angeles offer a fascinating glimpse into life in the Pleistocene epoch. The tar pits seem to have acted as a predator trap, with nine out of every 10 mammal remains excavated coming from carnivores. When a large herbivore such as a bison got stuck in the tar-filled swamp, its distress calls would have attracted predators like the sabre-toothed cat, *Smilodon fatalis*. There are some 130,000 fragments from an estimated 2,000 cats at La Brea, which almost certainly contain pretty good DNA. The snag is that oils have seeped into the bones, making that DNA difficult to extract. And even if it were possible to get hold of enough DNA, unleashing a top predator in our crowded world would be a highly questionable endeavour.

Plausibility: 2/5

Chance of ethical approval: 3/5

NEANDERTHAL

In 2010, researchers published a draft sequence of the Neanderthal genome, based on DNA fragments from three bits of bone that lay buried in a cave in Croatia for around 40,000 years. It's unlikely a nucleus could have survived in these conditions for that long, but this may not be a problem. The paper describing the Neanderthal genome noted places where the sequence of key genes differs from that of humans. Armed with this information and a technique known as site-directed mutagenesis, there's little to stop someone taking a human embryo and tinkering with it to make it look more like a Neanderthal – except ethical approval. But molecular biologists *could* build Neanderthal proteins in the lab by studying their structure and function.

Plausibility: 5/5

Chance of ethical approval: 1/5





map onto the way the climate was changing, and the way the vegetation was changing,” explains Professor Adrian Lister, a palaeontologist at the Natural History Museum in London.

Human interference

There is also some evidence that our ancestors had a hand in driving the woolly mammoth over the extinction precipice, with the discovery of spearheads lodged in bones. Then there’s the story of the last mammoths, which lends weight to the idea that humans were partly responsible for their extinction.

While the mammoth had virtually disappeared from mainland Siberia by about 10,000 years ago, rising sea levels cut a few animals off on what we now call Wrangel Island. DNA evidence indicates that a healthy population appears to have survived there – in the absence of people – for thousands of years. The end, when it came just 4,000 years ago, was swift and coincided with the arrival of humans on the island.

The question of what killed off the mammoths is of more than just

academic interest. In fact, the answer has a profound consequence for how we should view efforts to resurrect this shaggy, dome-headed beast.

“If we cannot establish beyond reasonable doubt that humans were involved in this extinction, the ethical impetus for doing this kind of work will pretty much evaporate,” says Dr Jeffrey Yule, an ecologist specialising in extinction studies at Louisiana Tech University in Ruston. He notes that if evidence suggested mammoths might still be around were it not for humans, the case for cloning would be easier to make.

Perhaps it’s inevitable that the excitement over well-preserved mammoth specimens and talk of cloning should eclipse a key question: should we want to bring this beast back at all? According to Dr John Fraser, president of the New Knowledge Organization in New York, would-be cloners have a moral responsibility to get this straight in their minds. He’s against the idea of resurrecting mammoths. “Mammoth recovery is silly intellectual gymnastics,” says Fraser, calling

The woolly mammoth was the first extinct species to have its genome sequenced

experiments “bio-stunts with extinct, lumbering oddities”. He points out that focusing on extinct organisms is a distraction from the plight of thousands of endangered species and threatened habitats around the world.

Conserving what we still have, says Fraser, is far more pressing. The idea of mammoth cloning, he says, is like “worrying about what the topping is going to be on your dessert, in the middle of a famine.”

A cloned mammoth would also raise serious welfare concerns. Putting one on show in a zoo would be grotesque, says Jeffrey Yule, as the mammoth was a highly social animal – nothing short of a whole herd would do. “If we’re going to be engaged in this sort of an enterprise, the medium- to long-term goal should be to return these animals to the wild.” Yet even if this were desirable, it’s far from clear whether they would survive at all in today’s warming world.

Given such an ethical minefield, it’s understandable that Sergey Zimov should have his reservations. The success of Pleistocene Park does not depend on mammoths – as he says, “We are reconstructing the ecosystem, not a single species.” But if scientists do successfully resurrect a mammoth, Zimov is prepared to climb off the fence and open the gate to his park. “If they produce mammoths, we will be able to take them.” ■

Dr Henry Nicholls is a science journalist and author of *The Way Of The Panda*

BBC
TWO

Woolly Mammoth airs on BBC Two at 9pm on 4 April and is on BBC iPlayer

FIND OUT MORE

<http://bbc.in/WooMam>

Watch BBC Nature videos about woolly mammoths

<http://j.mp/CloMam>

A mammoth-cloning timeline

HOW TO BUILD AN UNSINKABLE SHIP

Since the Titanic went down 100 years ago, science has been employed to make ships safer. **Paul Eastaugh** explores the cutting edge of marine technology

Building a boat that cannot be sunk may sound like a worthwhile goal, but put enough holes in a ship and it will always sink. The only reliable way to stay afloat is to avoid hitting anything by navigating safely, and ensure that nothing catches fire.

Ever since that fateful night in April 1912 when the RMS Titanic went down, the shipping industry has been working to make its vessels safer. The SOLAS (Safety of Life At Sea) regulations that followed the Titanic disaster have grown to cover a ship's smallest details. From a requirement for double hulls on oil tankers to the design of buckles on lifejackets, there's a regulation

to ensure all components are up to the job. Yet there's always room for improvement, and with global warming opening Arctic waters to oil exploration and shorter, cost-saving shipping routes, the need for safe ships is greater than ever. So with these icy routes in mind, what's the closest we can get to building something unsinkable?

We've cherry-picked the innovations that are transforming the safety of modern shipping to design a boat of our own. Some of these features are well established, while others are at the cutting edge and are yet to be widely introduced. You'd never see all of these on any one ship today, but this could be the shape of ships to come. ►



Paul Eastaugh is a journalist working in the marine and offshore industries. He has written extensively on aspects of marine technology for leading industry publications including *Safety At Sea*, *Shipping World* and *Shipbuilder*, *Maritime Journal* and *Fairplay International*



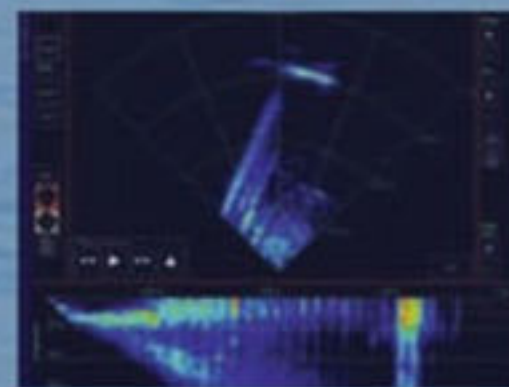
ON THE BRIDGE...



DIFFERENTIAL GPS

Pinpoint accurate navigation

GNSS (Global Satellite Navigation System) is the most important aid to maritime safety since the invention of radar. Signals received from satellite systems – GPS (USA), GLONASS (Russia), Galileo (Europe) or Compass (China) – are used to calculate location. Clever maths enables positioning that's typically accurate to 10m. To boost this accuracy, precisely located GNSS receivers on land identify any satellite signal errors and broadcast corrections, so that the entire system can be accurate to within 10cm.



FORWARD-LOOKING SONAR

Improving the view ahead

Unlike conventional sonars, which only show the seabed below the ship, the See Echo looks ahead to provide an advance warning of any obstacles. Small forward-looking sonars are sometimes used aboard luxury yachts, but the

See Echo is the first to be fitted to a large ship. It creates a 3D map of the sea ahead to reveal floating wreckage, containers and even whales, and sounds an alarm in time to change course. For Arctic voyages it will show the thickness of any ice ahead and reveal the best routes through it.



SHIP ARRESTOR

Controlling drift

A ship without power will drift helplessly and roll violently in rough weather, and may then lose its cargo and run aground. The ShipArrestor is a strong nylon sea anchor system that folds up compactly and can be launched automatically from the ship or deployed by a helicopter. The parachute-shaped anchor opens underwater to create drag that can quickly turn a ship into the wind and prevent its violent rolling. It can halve the speed at which even a supertanker will drift towards rocks, creating more time for rescue tugs to arrive and tow it to safety.

MAGNETIC PATCHES

Plugging leaks

Holes no bigger than a fist have sunk ships, but Miko Marine of Norway has the answer, with magnetic patches that create an instant seal. Magnetic rare earth particles impregnate a strong, flexible rubber compound that can be used to make patches of almost any size. They are carried by all Norwegian Coastguard vessels, one of which recently kept a nuclear fuel carrier afloat using one. If uneven damage prevents a magnetic patch from sticking, fabric patches reinforced with Kevlar and Aramide can be riveted in place by divers.

GRAPHENE HULL

Superstrong coating

Naval architects and shipbuilders are closely following the development of materials such as carbon-based graphene, which is 200 times stronger than steel. "Graphene has the potential to transform shipbuilding if it can be produced cheaply enough," said Patrik Wheeler, editor of *Shipping World and Shipbuilder*. "A ship built with this light but incredibly strong material could be very hard to hole, and would be lighter and use less fuel. It's too early to know whether this is realistic, but it's an exciting idea."



3D PORT DISPLAY

Virtual guide

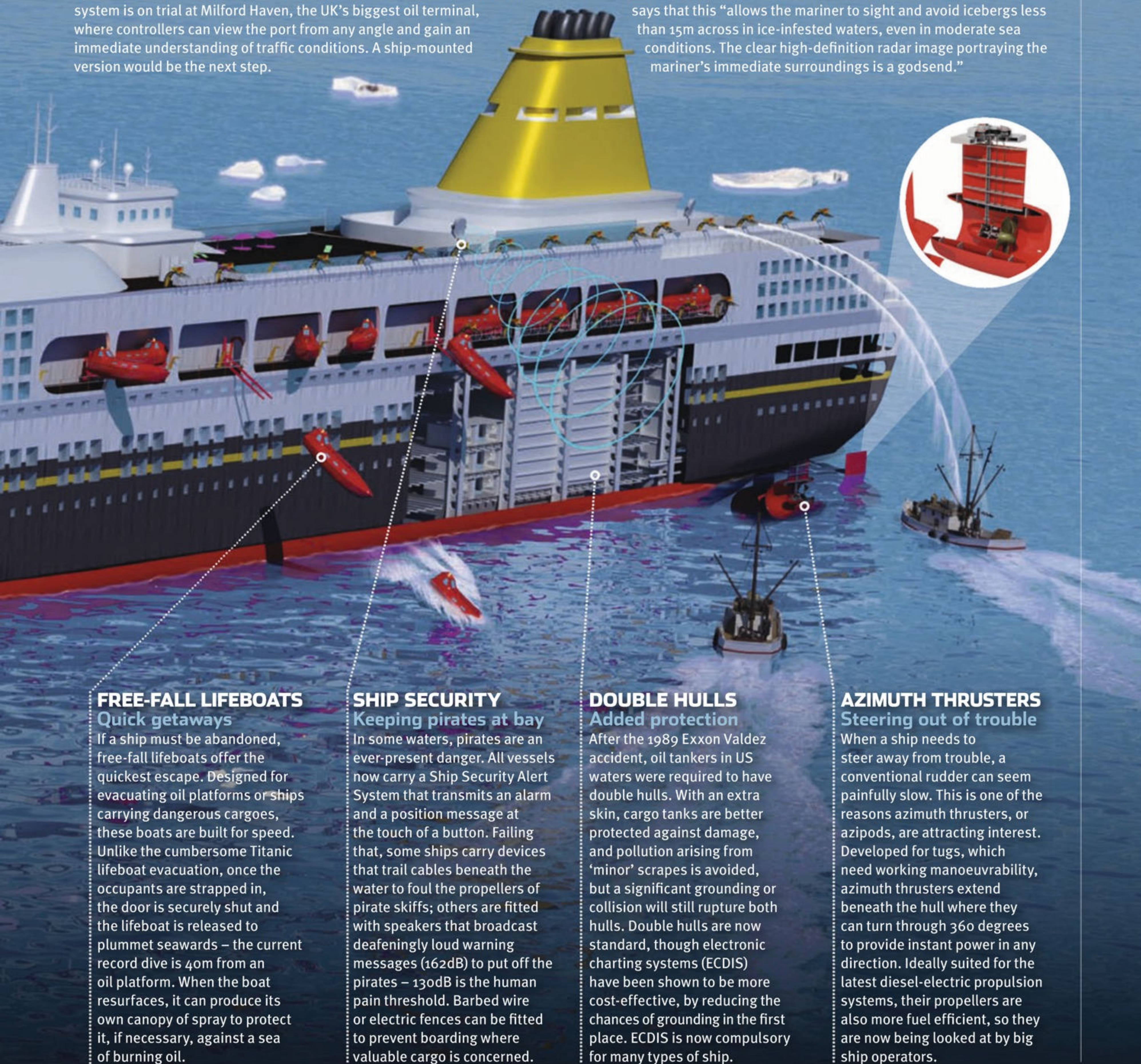
A mistake by a port operator can have devastating consequences. Highly sophisticated display software is now available that converts conventional radar, ship ID tags and electronic chart data into a virtual 3D panorama, so operators can understand what is happening at a glance. The first C-Vu system is on trial at Milford Haven, the UK's biggest oil terminal, where controllers can view the port from any angle and gain an immediate understanding of traffic conditions. A ship-mounted version would be the next step.



ICE RADAR

Spotting icebergs early

By reprocessing the same data from a conventional ship's radar many times, ice radar systems are able to overcome screen clutter and create displays that show ice height, cracks and weaknesses as a detailed, almost 3D image. Canadian Coastguard icebreaker captain John Vanthiel says that this "allows the mariner to sight and avoid icebergs less than 15m across in ice-infested waters, even in moderate sea conditions. The clear high-definition radar image portraying the mariner's immediate surroundings is a godsend."



FREE-FALL LIFEBOATS

Quick getaways

If a ship must be abandoned, free-fall lifeboats offer the quickest escape. Designed for evacuating oil platforms or ships carrying dangerous cargoes, these boats are built for speed. Unlike the cumbersome Titanic lifeboat evacuation, once the occupants are strapped in, the door is securely shut and the lifeboat is released to plummet seawards – the current record dive is 40m from an oil platform. When the boat resurfaces, it can produce its own canopy of spray to protect it, if necessary, against a sea of burning oil.

SHIP SECURITY

Keeping pirates at bay

In some waters, pirates are an ever-present danger. All vessels now carry a Ship Security Alert System that transmits an alarm and a position message at the touch of a button. Failing that, some ships carry devices that trail cables beneath the water to foul the propellers of pirate skiffs; others are fitted with speakers that broadcast deafeningly loud warning messages (162dB) to put off the pirates – 130dB is the human pain threshold. Barbed wire or electric fences can be fitted to prevent boarding where valuable cargo is concerned.

DOUBLE HULLS

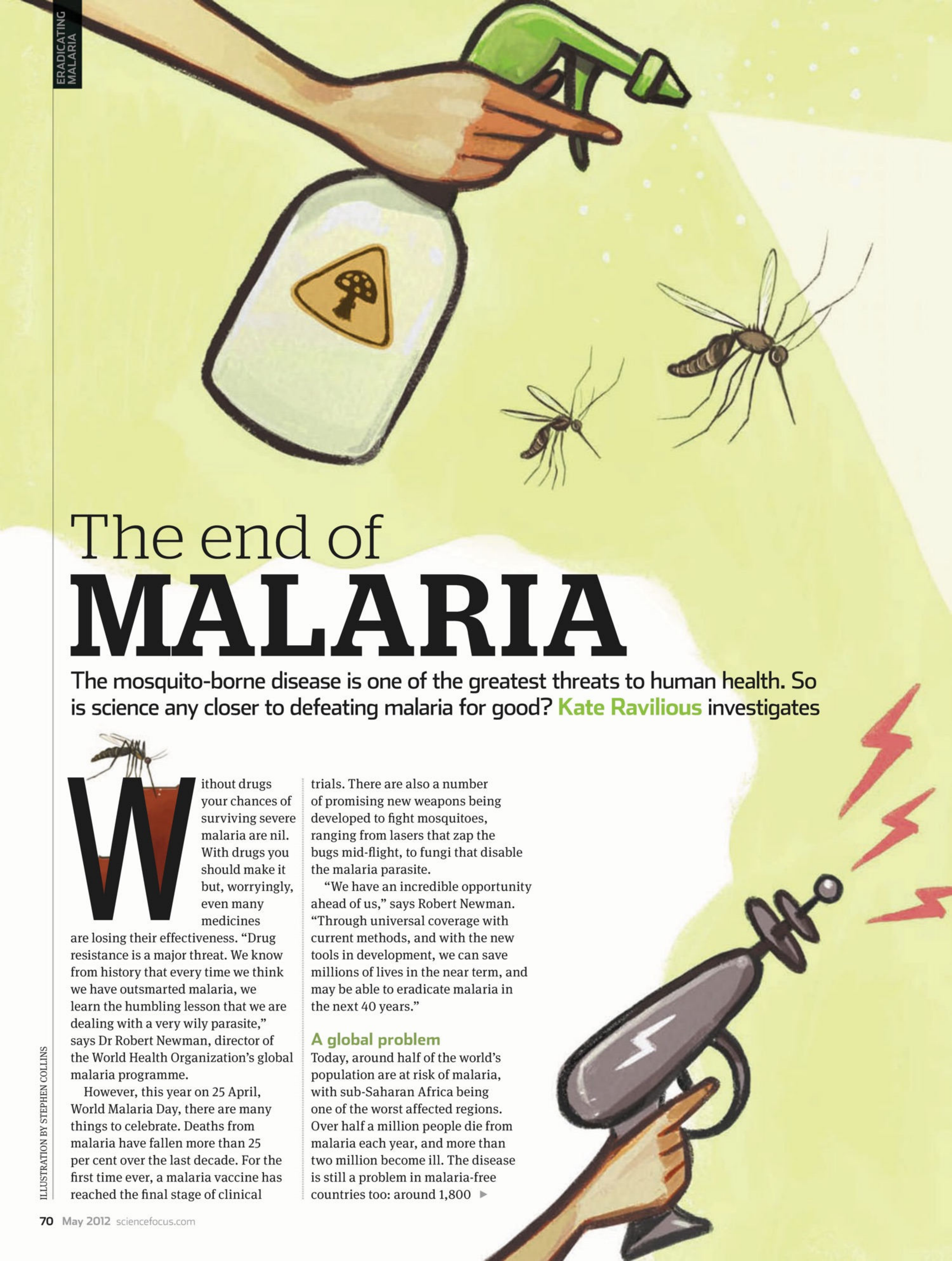
Added protection

After the 1989 Exxon Valdez accident, oil tankers in US waters were required to have double hulls. With an extra skin, cargo tanks are better protected against damage, and pollution arising from 'minor' scrapes is avoided, but a significant grounding or collision will still rupture both hulls. Double hulls are now standard, though electronic charting systems (ECDIS) have been shown to be more cost-effective, by reducing the chances of grounding in the first place. ECDIS is now compulsory for many types of ship.

AZIMUTH THRUSTERS

Steering out of trouble

When a ship needs to steer away from trouble, a conventional rudder can seem painfully slow. This is one of the reasons azimuth thrusters, or azipods, are attracting interest. Developed for tugs, which need working manoeuvrability, azimuth thrusters extend beneath the hull where they can turn through 360 degrees to provide instant power in any direction. Ideally suited for the latest diesel-electric propulsion systems, their propellers are also more fuel efficient, so they are now being looked at by big ship operators.



The end of MALARIA

The mosquito-borne disease is one of the greatest threats to human health. So is science any closer to defeating malaria for good? **Kate Ravilious** investigates

Without drugs your chances of surviving severe malaria are nil. With drugs you should make it but, worryingly, even many medicines are losing their effectiveness. “Drug resistance is a major threat. We know from history that every time we think we have outsmarted malaria, we learn the humbling lesson that we are dealing with a very wily parasite,” says Dr Robert Newman, director of the World Health Organization’s global malaria programme.

However, this year on 25 April, World Malaria Day, there are many things to celebrate. Deaths from malaria have fallen more than 25 per cent over the last decade. For the first time ever, a malaria vaccine has reached the final stage of clinical

trials. There are also a number of promising new weapons being developed to fight mosquitoes, ranging from lasers that zap the bugs mid-flight, to fungi that disable the malaria parasite.

“We have an incredible opportunity ahead of us,” says Robert Newman. “Through universal coverage with current methods, and with the new tools in development, we can save millions of lives in the near term, and may be able to eradicate malaria in the next 40 years.”

A global problem

Today, around half of the world’s population are at risk of malaria, with sub-Saharan Africa being one of the worst affected regions. Over half a million people die from malaria each year, and more than two million become ill. The disease is still a problem in malaria-free countries too: around 1,800 ►



► British travellers return home with malaria every year, nine of whom will probably die. Meanwhile, 'airport malaria' – malaria transmitted by stowaway mosquitoes – is expected to become more of a problem as global temperatures rise.

Malaria is caused by a parasite called *Plasmodium*. These ingenious free-loaders live in the salivary glands of the *Anopheles* mosquito. As the mosquito bites, it spits out saliva, transferring hundreds of parasites into the human victim's blood. From

there, the parasites hitch a ride down to the liver, where they set up home inside a liver cell, growing and multiplying over the following week. Once matured, as many as one million *Plasmodium* may burst forth, invading the body's red blood cells and clogging up the flow of oxygen to vital organs.

The tiny, single-celled parasite is a master of disguise. By altering the proteins on its surface, *Plasmodium* is able to change its appearance regularly to avoid being recognised by



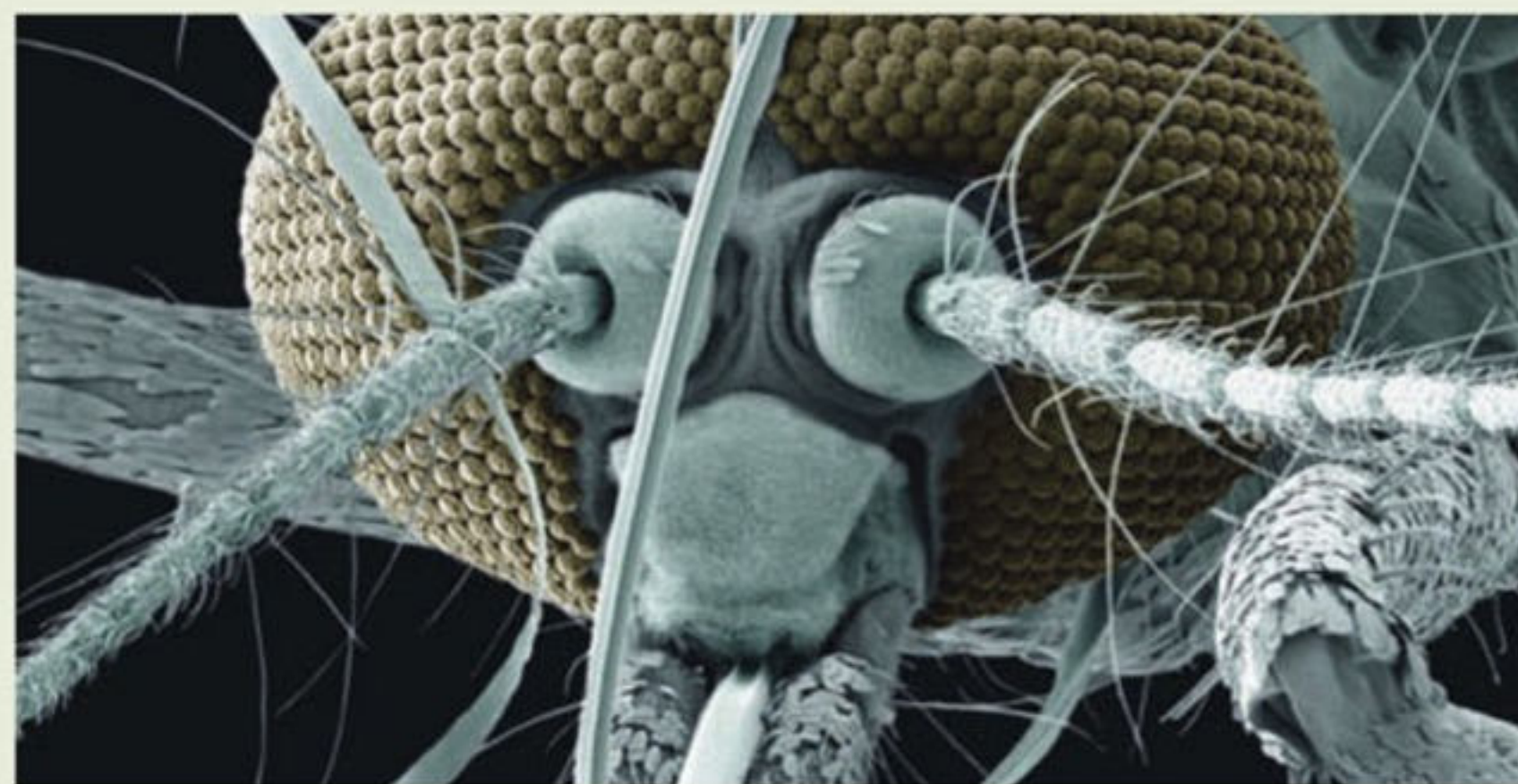
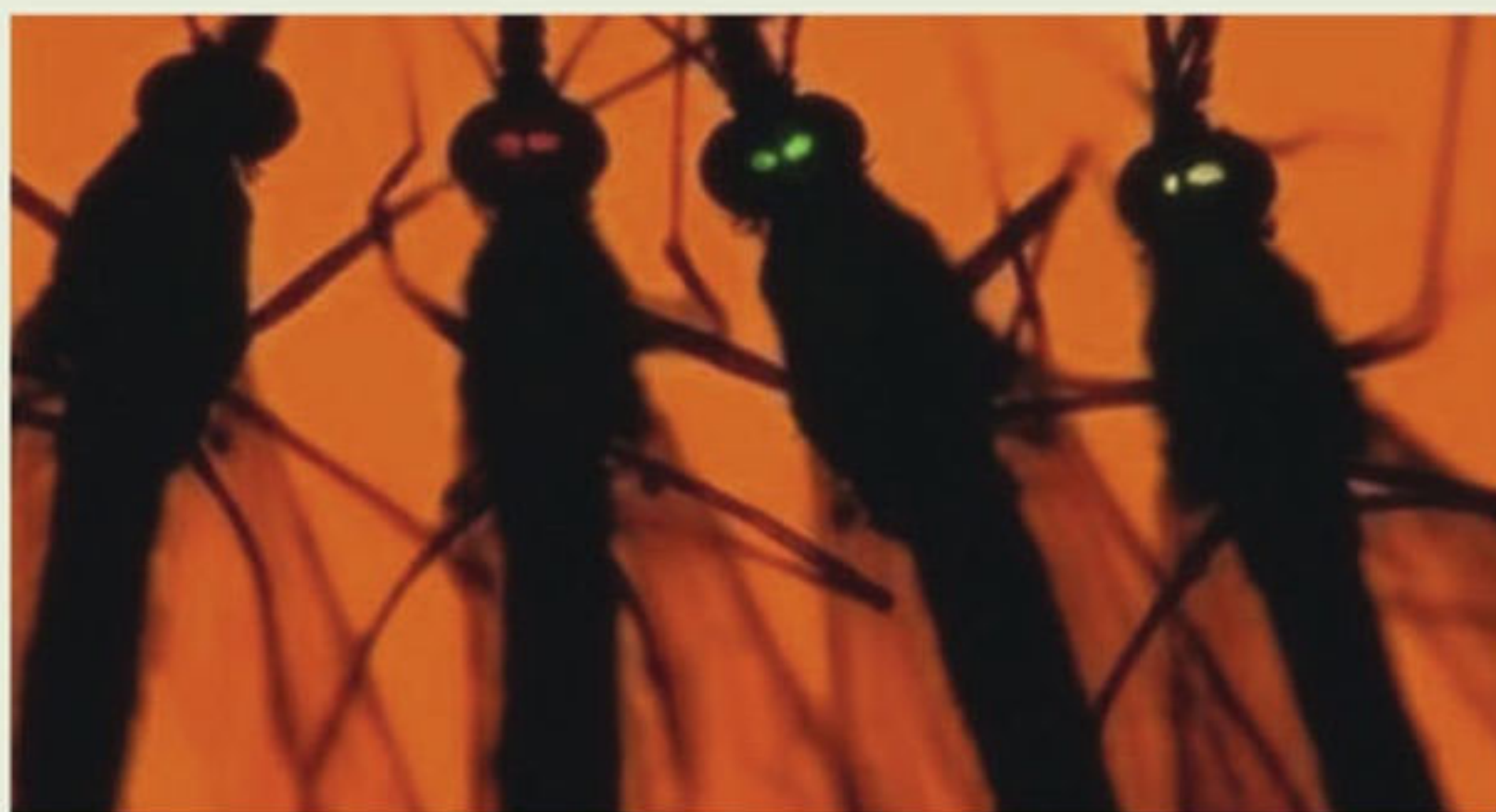
10% of people are especially enticing to mosquitoes, producing irresistibly scented sweat that the insects can detect from 30m away

our immune system. And its 5,000 genes are constantly mutating, developing resistance to all the drugs we throw at it. As a result, malaria was once considered too hard to beat.

But now two groups of researchers are getting tantalisingly close to producing a vaccine. The first of these vaccines is based on a strange

MOSQUITO MANAGEMENT

New approaches to stop transmission of the malaria parasite



GENETIC MODIFICATION

One way of stopping malaria is to help mosquitoes fight off the *Plasmodium* parasite. This is exactly what George Dimopoulos, from John Hopkins University in Maryland, is trying to do.

Last year Dimopoulos's team managed to genetically modify the immune system of an *Anopheles* mosquito (pictured), making it highly resilient to the *Plasmodium falciparum* parasite. They took one of the insect's own genes, and altered it so that the mosquito produced a faster and stronger immune attack when it fed on human blood. Studies in the lab showed that the GM mosquitoes became highly effective killing machines, preventing almost all *Plasmodium* parasites from taking up residence in their gut. Eventually, Dimopoulos envisages releasing a handful of the GM mosquitoes that would breed with their wild cousins – passing on their superior immune system with its malaria-resistant traits – in just a few generations.

Malaria is carried by over 40 different species of mosquito, however, and genetically engineering every species isn't feasible. Instead, the researchers aim to use the GM insect in regions where there's only one predominant species of malaria-carrying mosquito.

NOSE BLOCKING

Mosquitoes track down their victims by smell – homing in on odours of carbon dioxide and sweat. Now scientists are exploiting this fact, developing a chemical to block mosquitoes' sense of smell. Without their powerful 'nose', mosquitoes will be left milling around aimlessly, unable to find their next meal. The first stage has been to identify the odour receptors that the mosquito uses to sniff out its human prey.

Filippo Mancia from Columbia University and Vanessa Ruta from the Rockefeller University, both in New York, are using X-ray crystallography to reveal the atomic structure of the odour receptors on a mosquito's antenna. After mapping out the exact shape and structure of the odour receptor, the scientists will then use Bayer CropScience's database to search for chemicals with a mirror-image shape. These molecular mimics can latch onto the odour receptors, blocking the mosquito's 'nose'.

The end result will be the world's most effective insect repellent. "Ultimately we should be able to develop something that will prevent any insect bite, which could be used to tackle not just malaria, but all insect-borne diseases," says Dr Mancia.



phenomenon that was discovered in the 1970s. Researchers noticed that if mosquitoes were exposed to a blast of radiation, it damaged the DNA of *Plasmodium* in the mosquitoes' salivary glands. "People who were bitten by these irradiated mosquitoes developed immunity to malaria," explains Dr Stephen Hoffman, chief executive of Sanaria, a biotech company dedicated to creating a malaria vaccine.

Radiation stops the parasites from maturing normally. This prevents

them from using the shape-shifting ability that enables them to evade their host's immune system. And because they stay the same, our bodies are able to recognise the parasites as a foreign invader and develop an immune response.

For the last decade, Stephen Hoffman has been trying to mimic this effect and create a vaccine, using *Plasmodium* extracted from the salivary juice of irradiated mosquitoes. The company started in Hoffman's kitchen, but these days

"People bitten by these irradiated mosquitoes developed immunity to malaria"



it has labs and US headquarters in Rockville, Maryland, and a team of highly-skilled staff – all proficient at dissecting mosquito saliva glands. "One person can dissect around 100 in one hour," says Hoffman.

Results from its first clinical trial last year, in which 80 human volunteers were injected with the irradiated *Plasmodium*, were disappointing: just over five per cent of people achieved immunity. But a follow-up study in mice and monkeys resulted in over 70 per ►



KILLER FUNGUS

Mosquitoes are vulnerable to some types of fungus. Now researchers are taking advantage of this to genetically engineer a special fungus, designed to grab onto mosquitoes and block the exit route for *Plasmodium falciparum* – the most deadly form of the malaria parasite.

The specially souped-up fungus contains a protein that prevents the parasite from entering the mosquitoes' saliva glands, and an antibody to knock out the parasite. "Crucially, our fungus doesn't stop the insects from being able to breed, which should prevent their evolving a resistance to it," says Prof Raymond St Leger, from the University of Maryland. If the fungus did stop mosquitoes from breeding, it would trigger the insect's immune system to develop a resistance to the fungus – preventing the fungal proteins from attacking the malaria parasite.

In lab-based tests, *Plasmodium* was nearly completely eradicated from the saliva glands of mosquitoes dosed with the fungus. The researchers are now arranging permits to set up field trials in Burkina Faso, West Africa. They plan to construct giant domes covered in fungus-impregnated net, with the aim of creating a malaria-free zone inside the dome. As well as protecting humans, it could also protect livestock.



ZAP 'EM WITH LASERS

If all else fails, we could resort to frying mosquitoes using laser beams. Intellectual Ventures, the company belonging to Nathan Myhrvold, Microsoft's former chief technology officer, has already made a prototype – cobbled together from parts found in printers, digital cameras and projectors.

In a public demonstration at the 2010 TED conference in Long Beach, California, Myhrvold used the machine to gun down hundreds of mosquitoes contained inside a glass tank. The laser tracked the movements of the mosquitoes and then shot them down, with each mosquito going up in a plume of smoke. The team say that their device can shoot down between 50 and 100 mosquitoes per second.

Luckily the laser software is sophisticated enough to recognise its prey before shooting, preventing it from cooking butterflies, for example. It can even differentiate between male and female mosquitoes, ensuring that only the malaria-carrying females are killed. Myhrvold envisages using the laser to create protective 'fences' around people's houses, doctor's clinics, or perhaps even agricultural fields. They estimate that such a device could cost as little as \$50.

In Guinea, West Africa, malaria is the number one killer of children under the age of five



► cent immunity, when it was injected directly into a vein. So Hoffman's team is now conducting another clinical trial in humans, administering the vaccine intravenously.

Meanwhile, over at the GlaxoSmithKline labs in Belgium, Joe Cohen and his team are very close to producing a malaria vaccine too. Their potion, called Mosquirix, contains a fragment of *Plasmodium* from its blood-surfing stage inside the human body. When given the vaccine, our bodies learn to recognise the disguise worn by the parasite when it first enters, allowing us to arm our immune system ready to attack when the real thing arrives. "It only takes 30 minutes for *Plasmodium* to travel to the liver, so the body's defences have to act very quickly," says Dr Allan Pamba, a member of Cohen's team.

Preliminary results from phase III clinical trials (the final test) in over 15,000 young children look promising so far, cutting malaria rates by over 50 per cent. The trials are ongoing but, assuming no complications, the World Health Organisation has said that Mosquirix could be licensed as soon as 2015. "We are thrilled by these results

"This vaccine could save thousands of lives every year"



£8 billion

of Africa's economic output is lost due to malaria each year, equivalent to over one per cent of GDP in endemic countries

– this vaccine could save hundreds of thousands of lives every year," says Pamba.

A vaccine that confers 50 per cent immunity still leaves a lot of people vulnerable, however, and effective treatment would require more than just drugs. Currently, for example, malaria is often misdiagnosed because the initial symptoms are similar to a really bad case of the flu: fever, chills, headache, sickness and muscle pain.

Mobilising treatment

But if you're infected by the most deadly species of the parasite – *Plasmodium falciparum* – the disease can progress exceedingly rapidly, causing death within days. Diagnosing and treating malaria swiftly is clearly key to saving lives – and one tool that could help tackle the disease is the humble mobile phone.

Until now, many countries have used a paper-based system to track their medical supplies. In countries such as Tanzania, in East Africa, this has meant that around 40 per cent of clinics were out of malaria diagnosis kits and medicine at any one time, with new supplies sometimes taking months to arrive.

Modern gadgets could overcome this problem. A pilot programme in Tanzania (backed by IBM, Novartis



1/5th

of childhood deaths in Africa are caused by malaria, which kills one child every minute

and Vodafone) is thought to have saved hundreds of lives in just a few months last year, thanks to text messages, Google Maps and cloud computing software to track inventories of life-saving medications at remote clinics. It ensures that supplies are restocked before they run low. Such technological innovations, along with novel ways to tackle mosquitoes and new vaccines, will improve the lives of millions.

Ending malaria will come at considerable financial cost – GlaxoSmithKline has already spent \$300 million developing its vaccine over 25 years – but fortunately wealthy benefactors are committed to defeating the disease. Much of the progress on Mosquirix wouldn't have been possible without the philanthropy of the Bill & Melinda Gates Foundation, which donated \$200m to funding research. And with another \$50-100m from GlaxoSmithKline, the project will be complete.

Speaking at the Malaria Forum in October 2011, Bill Gates said, "Eventually, with relentless focus, we can eradicate malaria. We've already shrunk the malaria map considerably. We can make it disappear." Excitingly, it looks like he could be right. ■

Dr Kate Ravillious is a science writer based in York

FIND OUT MORE

www.worldmaliariday.org
World Malaria Day

<http://j.mp/malaser>
Video: Could this laser zap malaria?

Feed your mind



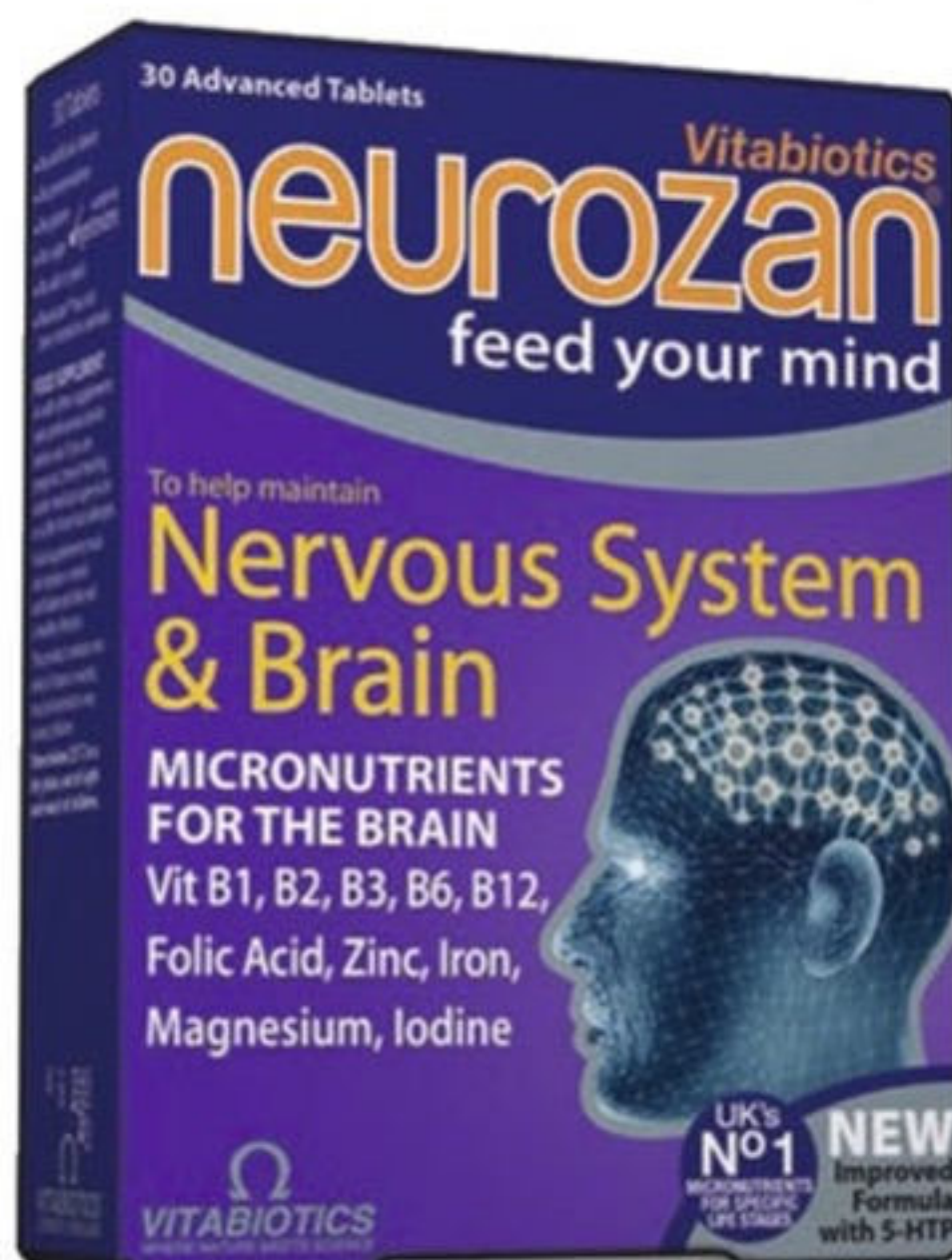
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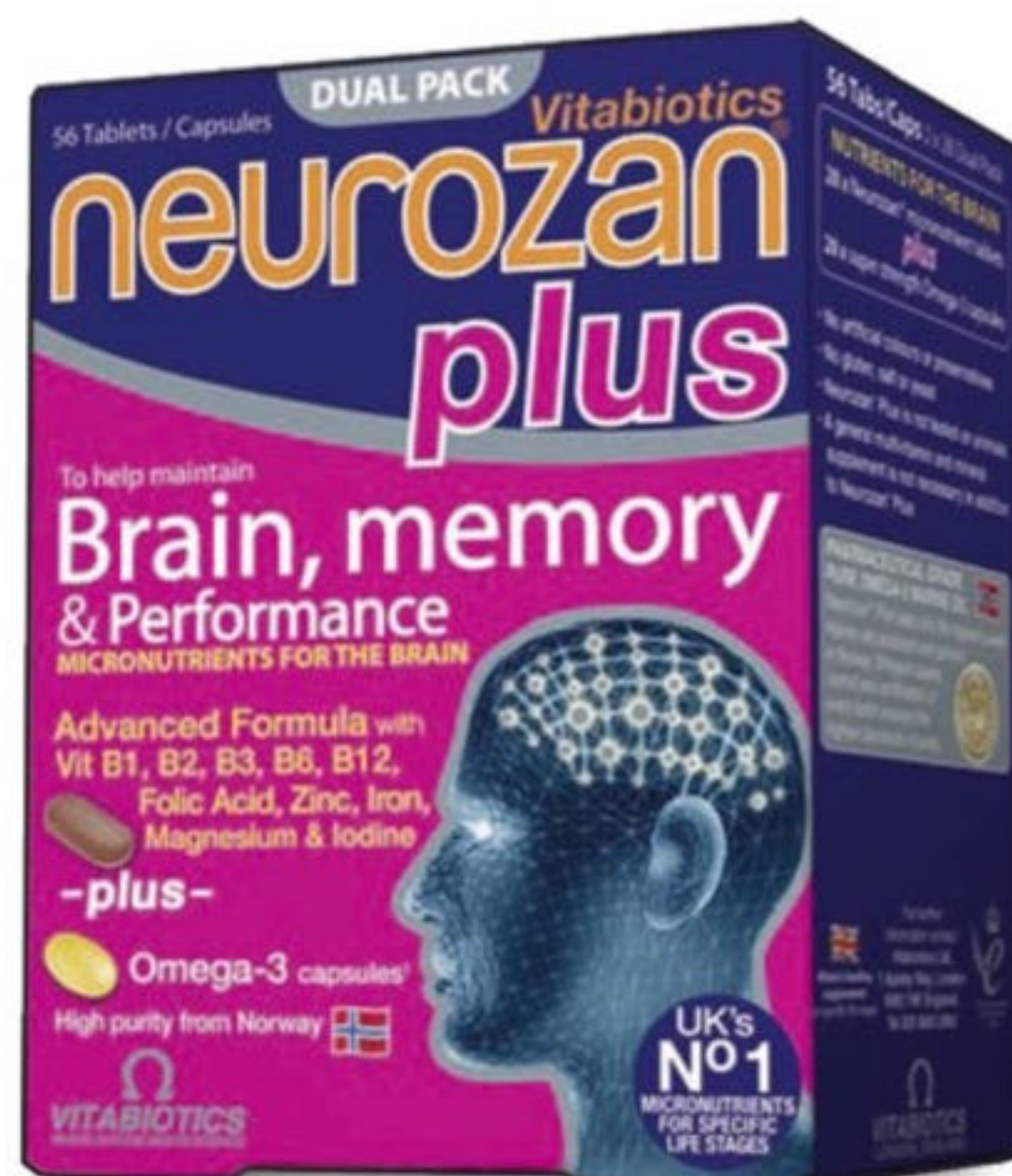
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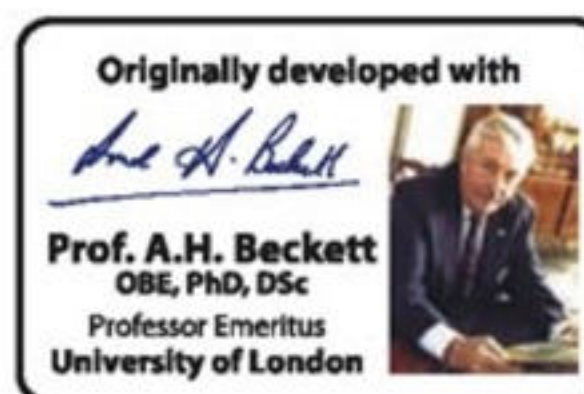


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Q&A

Your questions answered

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Can you 'bank' sleep in advance?

CLARE HASTINGS, BY EMAIL

BANK OF SLEEP

To a limited extent, yes. A 1991 study at Wright State University in Dayton, Ohio found that after an ordinary night's sleep, subjects could take an extra nap in the afternoon and then work through the night with greater alertness than a control group who didn't nap. The study also found that performance was proportional to the length of the nap – but the effect doesn't last.

After a second consecutive night without sleep, all of the subjects performed equally badly, regardless of how much sleep they had initially. It may be that all of us are normally slightly sleep-deprived and one really good night's sleep will bring us back up to 100 per cent, but that the 'tank' isn't big enough to buffer us against more than one all-nighter. **LV**

1 billion

The number of pixels the camera on the European Space Agency's Gaia probe will use to map the Milky Way in 2013.

Send us your questions

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The experts



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Susan is a visiting psychology professor at the University of Plymouth. Her books include *The Meme Machine*



DR ALASTAIR GUNN
Alastair is a radio astronomer at Jodrell Bank Centre for Astrophysics



ROBERT MATTHEWS
After studying physics at Oxford, Robert became a science writer. He's a visiting reader in science at Aston University



GARETH MITCHELL
Starting out as a broadcast engineer, Gareth now writes and presents *Digital Planet* on the BBC World Service

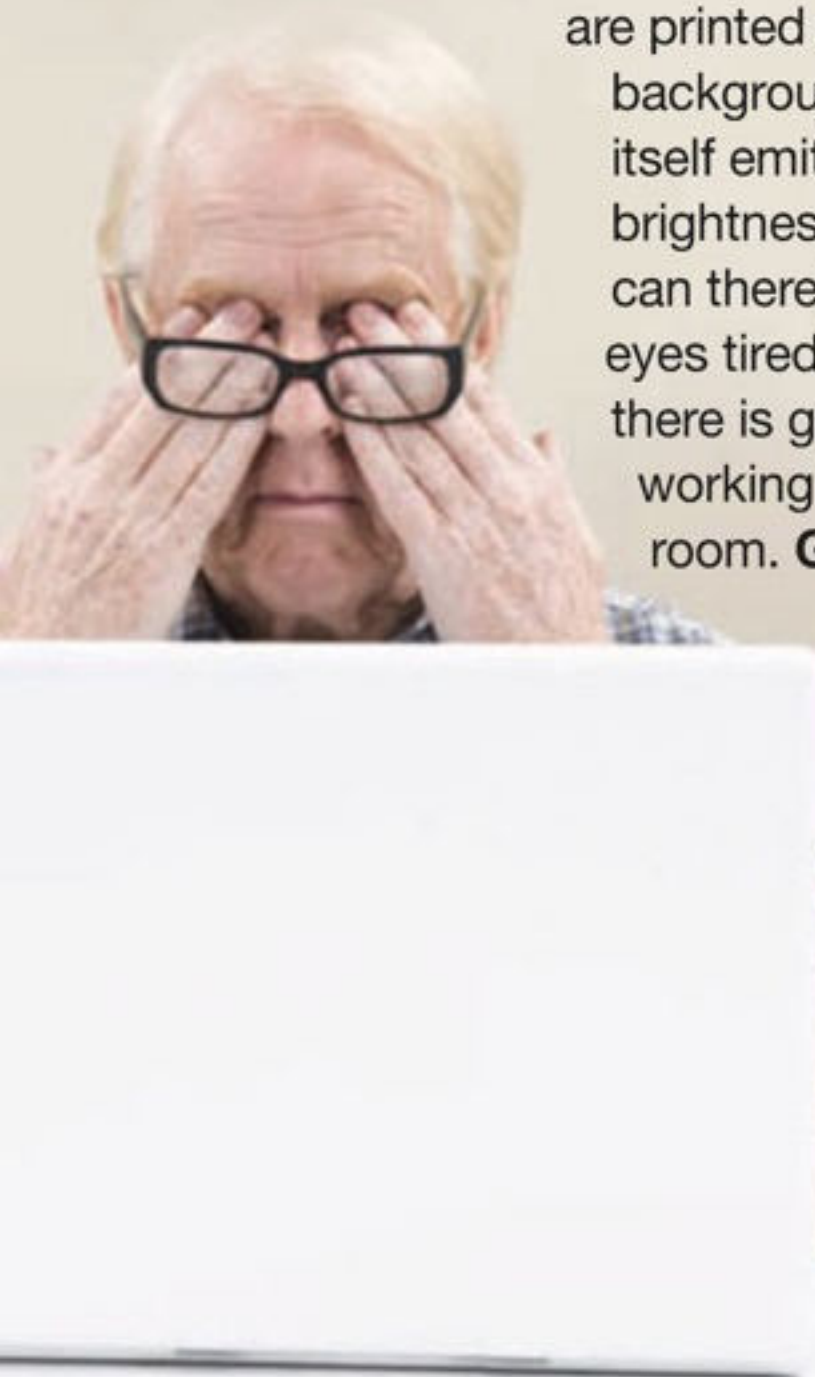


LUIS VILLAZON
Luis has a BSc in computing and an MSc in zoology from Oxford. His works include *How Cows Reach the Ground*

Why do computers make your eyes tired?

NICOLO STEWEN, IPAD APP

Eye-strain comes from a combination of screen flicker and the effects of frequently shifting your gaze around different parts of the screen. A computer display is usually wider than a book, making it harder work on the eyes. Also, unlike a printed page where dark letters are printed on a light background, the screen itself emits light. The brightness of the display can therefore make your eyes tired too, especially if there is glare or if you are working in a poorly lit room. **GM**



Can you dream in a language you don't speak?

CARLOS SANZ MINGO, BY EMAIL



Most dreams don't involve clear speech of any kind. Any 'speech' is just a jumble of concepts, intuitions and ideas that are understood by the characters in your dream without being fully articulated. It's quite possible to believe you are speaking a foreign language in your dream, but there is no reason to assume that it's any more real than the dream sensation that you can fly. **LV**

How many robots are there in the world?

SARA ROBERTS, CARDIFF

There are about 1.4 million industrial robots worldwide. They're high-end manufacturing bots costing tens or even hundreds of thousands of pounds. Many of them resemble human arms but have six axes of movement. Like the human arm, they can tilt up and down at the wrists, shoulder and elbow, and rotate at the wrist. But the elbow joint can also rotate and the whole assembly can rotate on its base. If you include devices like toys or automated vacuum cleaners, the robot population is more like 10 million. **GM**



Why is it so tempting to pick scabs?

ADAM SOANES, SHERBORNE

It is probably a manifestation of our natural self-grooming behaviour. Our ape relatives constantly examine themselves and each other for ticks, dirt and small wounds, and any deviation from the normal contour of the body invites deeper scrutiny. The mild pain associated with picking a scab also releases endorphins, which can act as a reward. Scab picking, like many grooming behaviours, is also a displacement activity that can help to distract us when we are bored, stressed or anxious. Those who suffer from obsessive-compulsive disorder (OCD) may find it hard to stop picking even when it is unsightly or causes further injury. **LV**

Do animals sweat?

WILL RICHARDSON, BY EMAIL



Some do, some don't. Many mammals, including most primates, sweat to regulate their temperature when too hot, but few do so as much as humans and horses. Even though we use the expression 'sweat like a pig', pigs have very few functional sweat glands, which is why they like to roll in water or mud when they are too hot.

Bears have sweat glands, but dogs have very few and instead cool themselves by panting, which evaporates water from the mouth and tongue. Cats sweat through their paws and also cool themselves by washing.

Birds also lack sweat glands and stay cool by panting, raising their feathers and cooling from their legs and feet. Reptiles and insects have no need to sweat because, unlike mammals, they don't need to maintain a constant body temperature. **SB**

Can science explain luck?

NICHOLAS VLASTOS BY EMAIL



If you throw a die and it falls down, that's not luck, that's gravity. But calculating exactly which number ends face up requires you to know all the forces involved, the movement of the air molecules and so on. That's much too hard to do in the time it takes for the die to land, so we commonly say that it's down to 'chance'. This means that there are too many parameters to figure out the outcome of the event in the given time, or we can't calculate them accurately enough.

'Luck' is the word we use to describe the particular outcome of a chance event. If a die rolls a 6 we might call it good luck, if it rolls a 1, we might call it bad luck. But if every number has the same probability of rolling, then 'luck' is just a story we tell ourselves to make sense of the event retrospectively.

Humans are story-telling animals. We look at the world as a narrative, usually with ourselves at its centre. The science of psychology has something to say about why we find luck such an attractive concept, and maths can explain why some random events happen more often than we intuitively feel they should. But physics can't explain luck itself, because it is a fiction of our own making. **LV**



Can flies fly upside down?

ALAN DAWES, IPAD APP

No. That's not because it would be aerodynamically impossible with their existing wing arrangement – it's just not something that would be particularly useful for them to evolve to do. Coordinating high-speed flight with a tiny insect brain is already difficult enough the right way up. When flies land upside down, what they actually do is just grab the ceiling with their front legs at the last minute, and then do a backflip. **LV**

Why are some egg yolks brighter than others?

JANET HULL, BY EMAIL

The colour of the egg depends on the diet of the hen. Plant pigments called xanthophylls (which just means yellow pigment) are present in all green plants to some extent, but a diet that includes corn or flower petals will result in deeper yellow egg yolks. The same mechanism is responsible for the yellow skin of corn-fed chickens. Marigold petals and alfalfa are often included in commercial poultry feed. **LV**





Can you see Earth's curvature on the ground?

DAVE CANAVAN, BY EMAIL

At sea level, anything further than about four kilometres will begin to dip below the horizon, so the funnels of a distant ship poking above the horizon are evidence of Earth's curvature. Assuming no headlands interrupt your view, you can see 180.78° of sky at the horizon, instead of just the 180° you'd see if the Earth were flat. Over such a wide vista, however, the effect is

so subtle that it's hard to be sure you're not just imagining it. At the top of a 1,000m hill, the horizon encompasses 182° , but that's still barely noticeable.

However, you *can* stand on the ground and look up at the Moon during a lunar eclipse. The shadow cast by the Earth is circular, so the curvature is clearly visible then. **LV**

Why do your ears sometimes 'ring'?

LORRAINE DAVID, BY EMAIL

Loud noises, including music, fireworks and machinery, can damage hair cells in your inner ear. These transform sound into neural impulses that travel to the brain, and loud noise can literally break their ends. They usually grow back in about 24 hours, but while broken they send false signals to the brain. Tinnitus (Latin for ringing) can also be caused by ear infections, certain medications and gradual impairment due to ageing. **SB**



DID YOU KNOW?

Minor planet Pluto and its moon Charon form the only true planetary binary system in the Solar System. Charon is so large in relation to Pluto that the central point around which they both orbit lies above the surface of Pluto, rather than within its body.



QUICKFIRE

Does environment affect the taste of alcohol?

JAKE ROWLER, READING

Yes. Publicans have long known that they can sell more drinks in noisy bars, but not why. New research in which people rated the flavour of drinks in different environments suggests this is not just because you drink more when the noise makes conversation nigh-on impossible, but also because alcohol actually tastes sweeter in noisier environments. Since we have an innate preference for sweetness, we drink more. **SB**

How much Helium-3 is there on the Moon?

PATRICK FULLER, LONDON

It is difficult to be sure how much of this important isotope of helium may be on the Moon. But some studies suggest Helium-3 (^3He) concentrations may reach 50 parts per billion in permanently shadowed regions. A more conservative estimate implies that in every 150 tonnes of lunar soil there may be 1 gramme of ^3He . This suggests there may be over a million tonnes of lunar ^3He available for mining. **AG**



What is a 'peculiar' galaxy?

MARY LONGFORD, BY EMAIL

A 'peculiar' galaxy is one that doesn't fit easily into the normal classification system of galaxies. Peculiar galaxies have some oddity in their size, shape or content that sets them apart, and are often the result of interactions or collisions with other galaxies. They may contain unusual amounts of dust, have low surface brightness or jets of material emerging from their cores. **AG**

THINGS YOU THOUGHT YOU KNEW

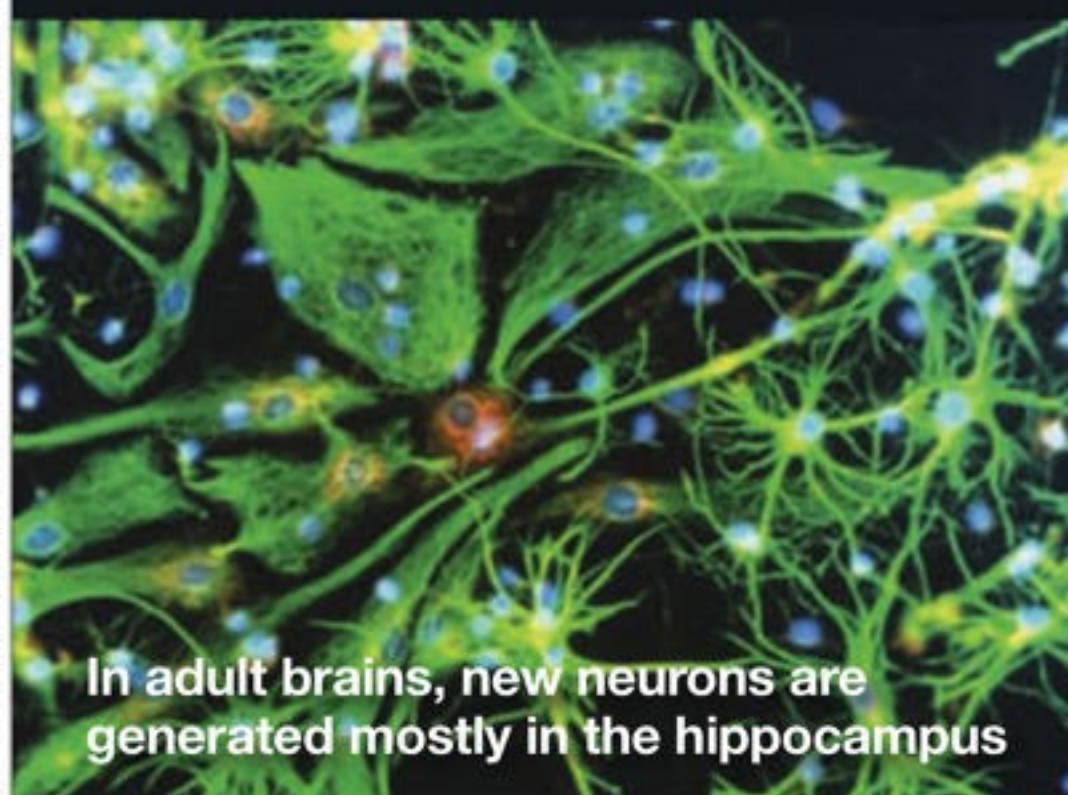
Can brain cells regenerate?

For more than a century, it was a mantra of biology: brain cells do not regenerate. It was thought you were born with all the brain cells you would ever have, and if one died it would never be replaced. Some people still think this today – despite many studies showing that neurogenesis, the creation of new brain cells, does occur in adults.

Evidence for neurogenesis in adult rats, songbirds and monkeys began to emerge in the 1960s, but it was a study published in *Nature Medicine* in 1998 that proved conclusive regarding humans. Neurobiologist Fred H Gage of the Salk Institute, California led a team that looked at human brain tissue from postmortem patients, taken from regions that had been shown to be neurogenic in adult rodents and monkeys. The work showed that new neurons were generated from dividing progenitor cells in the hippocampus – a region deep within the brain involved with learning and memory.

Since then, research has shown that the hippocampus is the most active area of neurogenesis in the human brain. Thousands of new cells are produced there every day, although many die within weeks of their 'birth'. Those that survive do so by connecting with existing neurons, suggesting the potential for a self-healing brain. Today, researchers are trying to harness and enhance neurogenesis in order to find better treatments for disorders such as epilepsy and Alzheimer's disease.

So yes, brain cells do regenerate. What's more, you can actively encourage the process. The more physical and mental exercise you get, the more brain cells you grow, the longer they survive and the better they connect with other nerve cells.



In adult brains, new neurons are generated mostly in the hippocampus

Why doesn't a mirror reverse top to bottom?

JOHN BELL, IPAD APP

This seemingly tricky question has caused arguments since at least the time of Aristotle, 2,300 years ago. But in essence, the explanation is simple. Mirrors don't reverse up and down – and, in fact, they don't reverse left and right either. They simply show us our reflection, and that appears to reverse the direction we're pointing. The reason this also seems to reverse left and right is because these two directions are defined relative to our own direction.

Don't believe it? Then stand opposite someone else and both lift your right arms: you'll initially think that the other person has lifted the 'wrong' arm. They haven't: it's just that they're pointing in the opposite direction to us – so their idea of left and right no longer agrees with ours. It's the same when you're looking in a mirror; your reflection created the illusion of reversing your direction. **RM**



DID YOU KNOW?

The world's fastest trains run between the cities of Guangzhou and Wuhan in China, with an average speed of 350km/h (217mph). Japan's famous 'bullet trains' manage just 243km/h (150mph), while the top speed ever recorded by a Eurostar train was 335km/h (208mph).



How much net energy does a wind turbine produce?

RICHARD GILLHAM, BY EMAIL

Wind farms can produce electricity whenever wind speeds are between around 8 to 50km/h – which is around 75 per cent of the time. The trouble is that the wind doesn't blow at a constant rate for all of that time, and consequently often falls below the optimum speed for electricity production.

As a result, a wind turbine rated at, say, two megawatts typically has a much lower average output over the course of a year, amounting to just 30 per cent of this 'installed capacity' figure, or around 600 kilowatts.

Critics of wind power add that even these average figures mask the impact of meteorological conditions. For example, bitterly cold weather can frequently coincide with high pressure systems, which leads to there being virtually no wind at all – and therefore no power from wind turbines, just when it's most needed. **RM**



Is it possible to have a triple rainbow?

BEN BROOKS, BY EMAIL

When sunlight strikes raindrops, we often see not just one vivid rainbow but another, fainter one lying beyond it. This is the result of light entering raindrops and striking their inner surfaces a second time before re-emerging.

In principle, this could happen a third or even fourth time, so why don't we see triple or even quadruple rainbows? The

reason is that the extra reflections make such rainbows even fainter – and what's worse, ensure the resulting rainbow appears around the Sun.

Not surprisingly, there have been only five reports of 'tertiary' rainbows over the last 250 years. But in 2010, American meteorologists Raymond Lee and Philip Laven called for a search for tertiary

rainbows during thunderstorms in which the Sun broke through thick, raindrop-laden clouds, predicting that such conditions give the best chance of seeing tertiary rainbows.

Sure enough, more reports of these elusive phenomena have now emerged – and, in one case, even a photograph showing a quaternary rainbow. **RM**

1 in 8

Chance of a huge solar flare equivalent to 1859's Carrington Event occurring in next 10 years

Are there any mobile phone masts in Antarctica?

LAURENCE CABLE, BY EMAIL

A few. Most of the scientists working there use VHF radios to communicate with each other and satellite phones to connect to the rest of the world. None of the British or US research stations have mobile phone masts at the moment, but Marambio Base, run by Argentina, has an analogue mobile phone connection to South American networks, and the Australian Mawson Station and Casey Station have GSM phone masts. **LV**



Is it true that global warming causes CO₂ increases, not vice versa?

JACKIE MALDOON, BY EMAIL

Global warming focuses on how increasing levels of greenhouse gases – especially carbon dioxide (CO₂) – trap more of the Sun's heat, causing the Earth to warm up. Yet for years, sceptics of global warming science have pointed to an odd fact about the relationship between temperatures and CO₂ levels, as revealed by analysis of ice-cores from sites in the Antarctic. These show that over the last 400,000 years, the temperature rises and falls centuries before changes in the CO₂ levels – rather than the other way round, as would be expected if greenhouse gases are the cause of the temperature changes.

In reality, the ice-core data are exactly what climatologists expect to see over such vast timescales. Put simply, they're showing the effect of very long-term changes in the orbit of the Earth about the Sun, which trigger cyclic changes in both global temperature and greenhouse gas levels. In contrast, the concern about global warming focuses on the sudden increase in CO₂ levels caused by human activity over just the last century. This change is much more dramatic than the slow, cyclic changes revealed by the ice-core data, and its effects could potentially be much more serious – which is why climate experts are so concerned about it. **RM**



How often do the planets in our Solar System line up?

TOM RYAN, LIVERPOOL

The answer to this question depends on how we define 'line up'. Because the planets orbit the Sun with slightly different orbital inclinations, it is extremely unlikely they will ever align perfectly – the odds of this happening are something like one in 86 billion trillion trillion trillion years! However, if by 'line up' we just mean that some of the planets appear close together in the sky, then this occurs fairly regularly. For example, the five naked-eye planets cluster within 25 degrees or less of each other once every 57 years, on average. The last time this happened was on 5 May 2000; before that it was 4 February 1962, and it will happen next on 8 September 2040. But these are not true planetary 'alignments', they are simply interesting and beautiful groupings of the planets in the sky. **AG**

Why do all stars appear to spin around the North Star?

FELIX JONES, SHEFFIELD

The apparent circling of the stars around the North Star (Polaris) is an illusion caused by the rotation of the Earth. Our planet's north pole happens to point at a spot on the sky very close to Polaris (astronomers call this spot the 'north celestial pole'). So, as the Earth spins, Polaris will appear to remain still while the other stars circle it once in slightly less than 24 hours. The further from Polaris a star is, the larger the circle around it will be.

Polaris isn't exactly at the north celestial pole. So it too traces out a tiny circle in the sky. In fact, the position of the north celestial pole is constantly changing. Since the Earth's rotation axis itself 'precesses' like a spinning gyroscope, the pole traces out a large circle on the sky every 25,772 years. So although Polaris is near the pole now, in 12,000 years the star Vega will be the closest bright star to the pole, and will be the new 'North Star'. **AG**

120 million

years is the age of a new type of Pterosaur fossil recently discovered in northeast China

What makes you start running instead of walking fast?

JAMIE RAIKES, BY EMAIL

When you walk, one foot is in contact with the ground at all times. With each stride, the foot that is moving forwards is preparing to release muscle energy to drive the leg backwards against the ground and push your body forwards. Part of that preparation involves the gastrocnemius muscle in your calf, which pre-stretches the Achilles

tendon in your heel, to store elastic energy.

As you walk faster, your stride length stays roughly the same but each individual stride takes less time. This gives the gastrocnemius less and less time to stretch the Achilles tendon and so it has to work harder, which is less efficient. So at a certain speed – usually around 2m/s

(4.5mph) – it is better to break into a run. When running, both legs are off the ground at the same time, which enables you to lengthen your stride. The gastrocnemius muscle now has more time to contract, so even though you are moving faster, the gastrocnemius is contracting more slowly. This is more efficient, and therefore less tiring. **LV**



How are sinkholes formed?

In May 2010, a vast hole appeared overnight in the heart of Guatemala City, swallowing an entire three-storey building, a neighbouring house and one unlucky bystander. Measuring over 18m across and 100m deep, this enormous void was a dramatic example of a geological phenomenon known as a sinkhole.

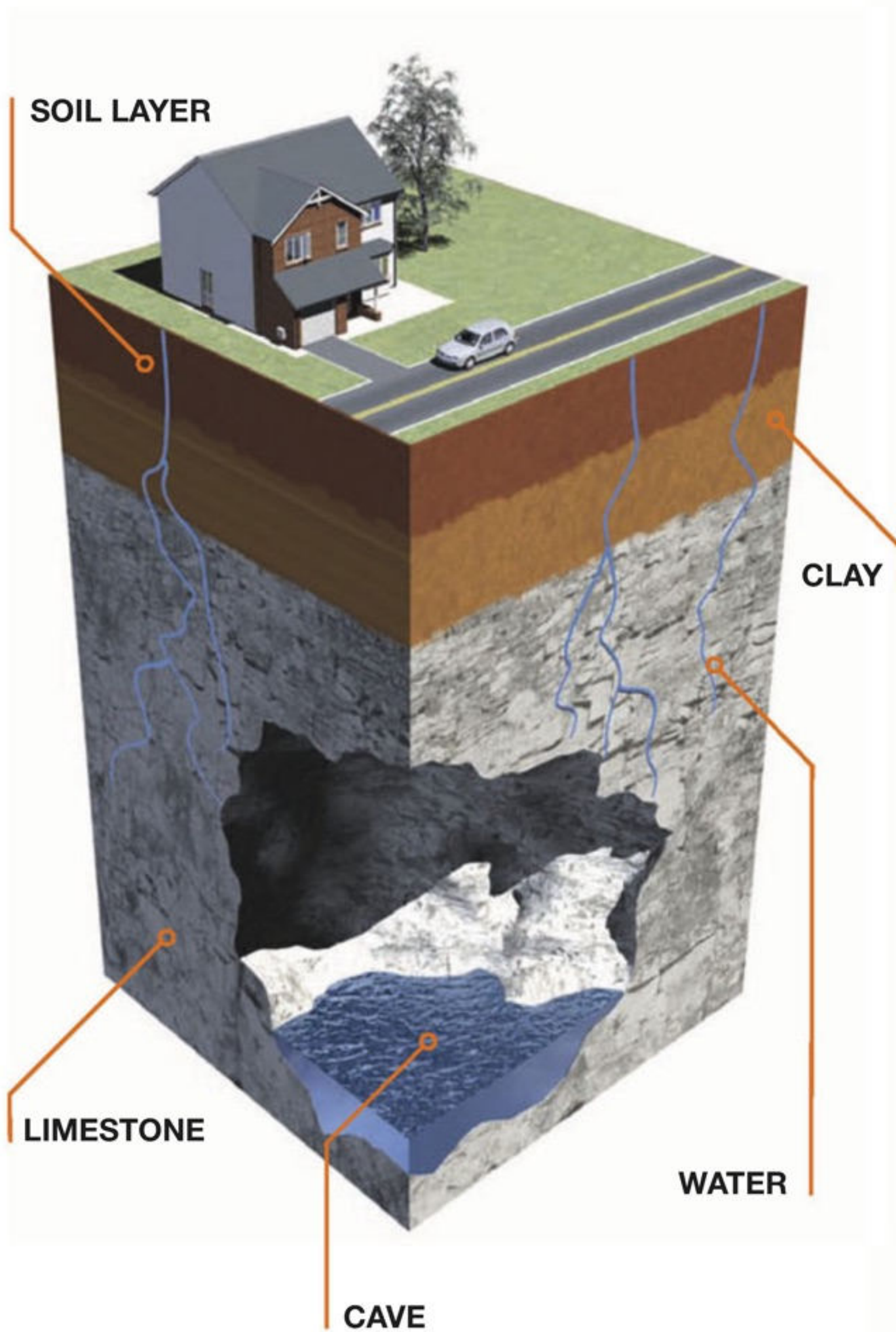
Sinkholes occur across the globe, and although huge, the Guatemalan sinkhole pales in comparison to some others. For example, at up to 352m wide and 314m

deep, the four Sarisarinama sinkholes in Venezuela are so large that forests have sprung up within their depths, complete with ecosystems that are very different from the surrounding terrain. It is not known when these holes appeared – they were first spotted, from a plane, in 1961.

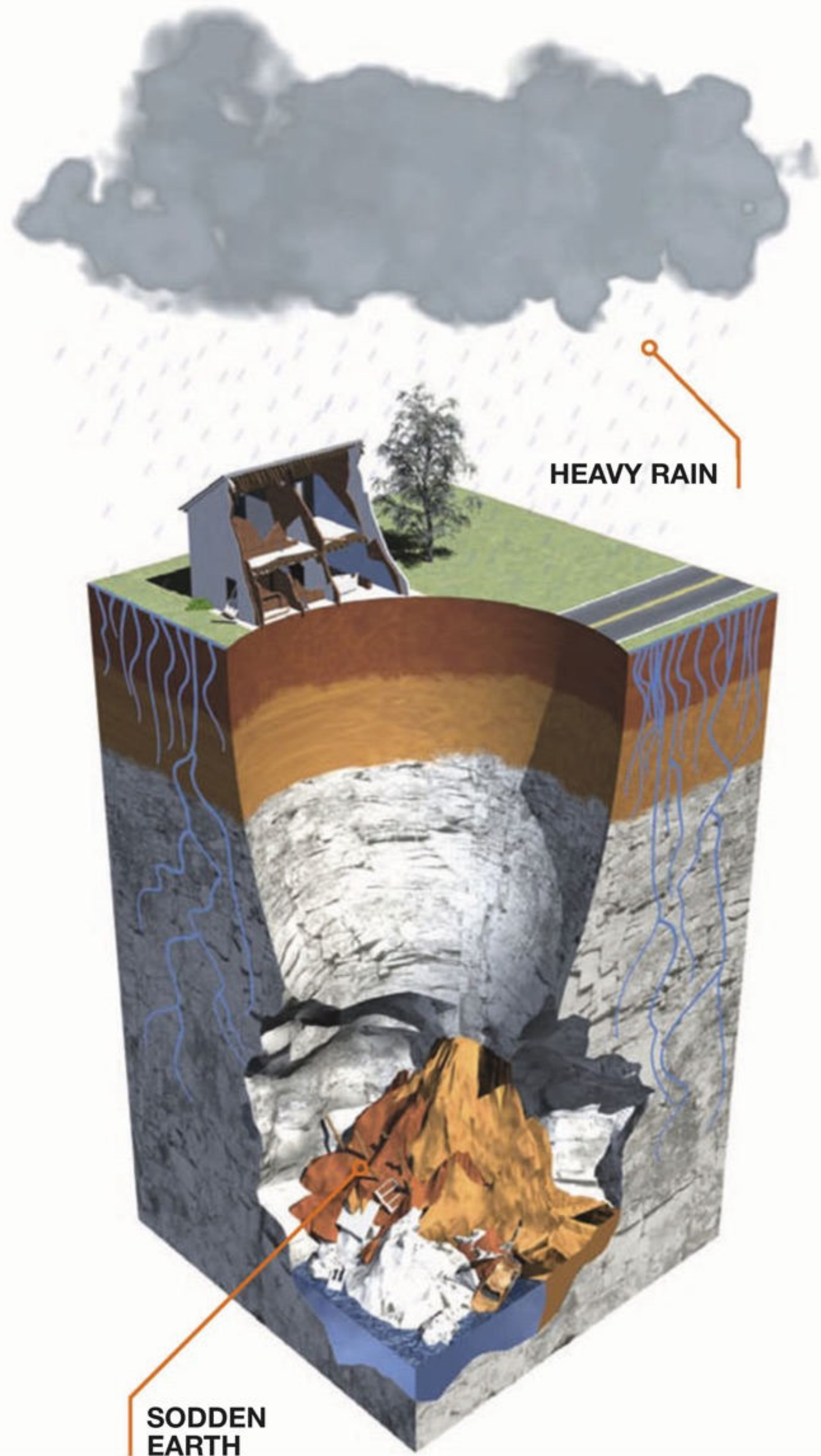
In most cases, for a sinkhole to occur, the geological composition of the earth must be just right. The topsoil must be soluble enough to allow water to drain through it, and the bedrock below porous

enough to absorb the liquid. Over time, this water begins to erode the limestone or carbonate bedrock from the bottom up, forming a cave, the roof of which supports the soil above. As happened in Guatemala City, very heavy rainfall can then saturate the topsoil to the point where the roof of the cave will collapse without warning.

Water erosion acting in this manner causes most sinkholes, but some can also be caused by human interference, or by other geological factors.



A soluble layer of clay and topsoil enables water to pass through to underlying rock. Eventually the rock is dissolved, forming a cave. Over time, the roof of this cave collapses to form a sinkhole.



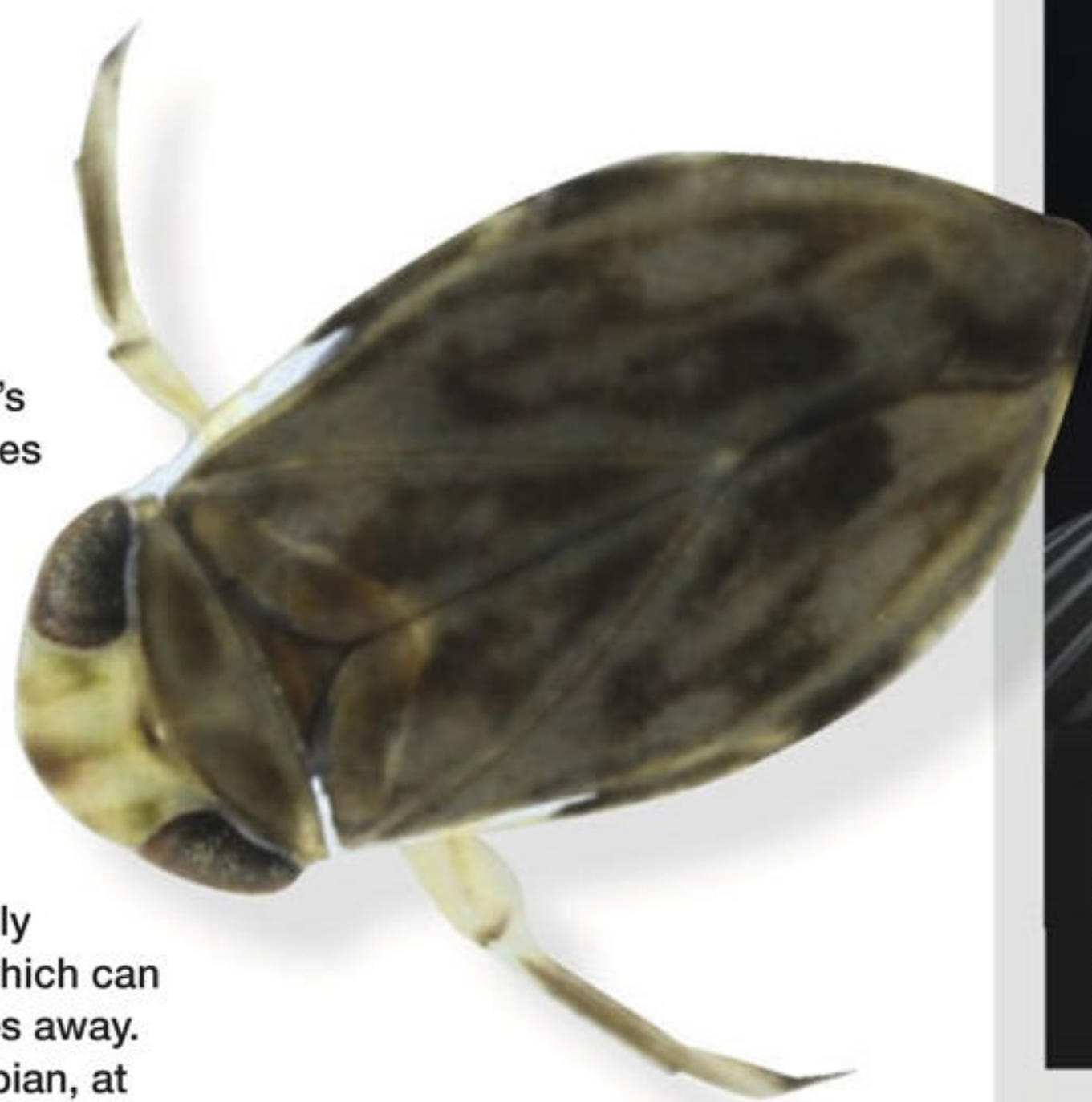
What is the noisiest animal in the world?

AMIRHASSAN MONTAZER, IRAN

That depends what you mean by noisiest, but if you mean loudest then the Smithsonian National Zoo in the USA reckons that the blue whale's low-frequency pulses win. At up to 188 decibels (dB), they are louder than a jet engine and can be detected over 500 miles away. On land, the loudest animals are probably howler monkeys, which can be heard three miles away. The loudest amphibian, at 100dB, is the common coqui frog native to Puerto Rico.

Similarly loud among birds are oil birds, which live in caves and use echolocation, like bats. Their clicks and squawks can reach 100db, and thousands of them nest together. One species of

water boatman, the size of a grain of rice, can 'sing' at 103dB by rubbing his penis against his belly in a process similar to how crickets chirp. This is the loudest known sound relative to the animal's size. **SB**



What causes headaches?

SARAH PERRY, ASHFORD

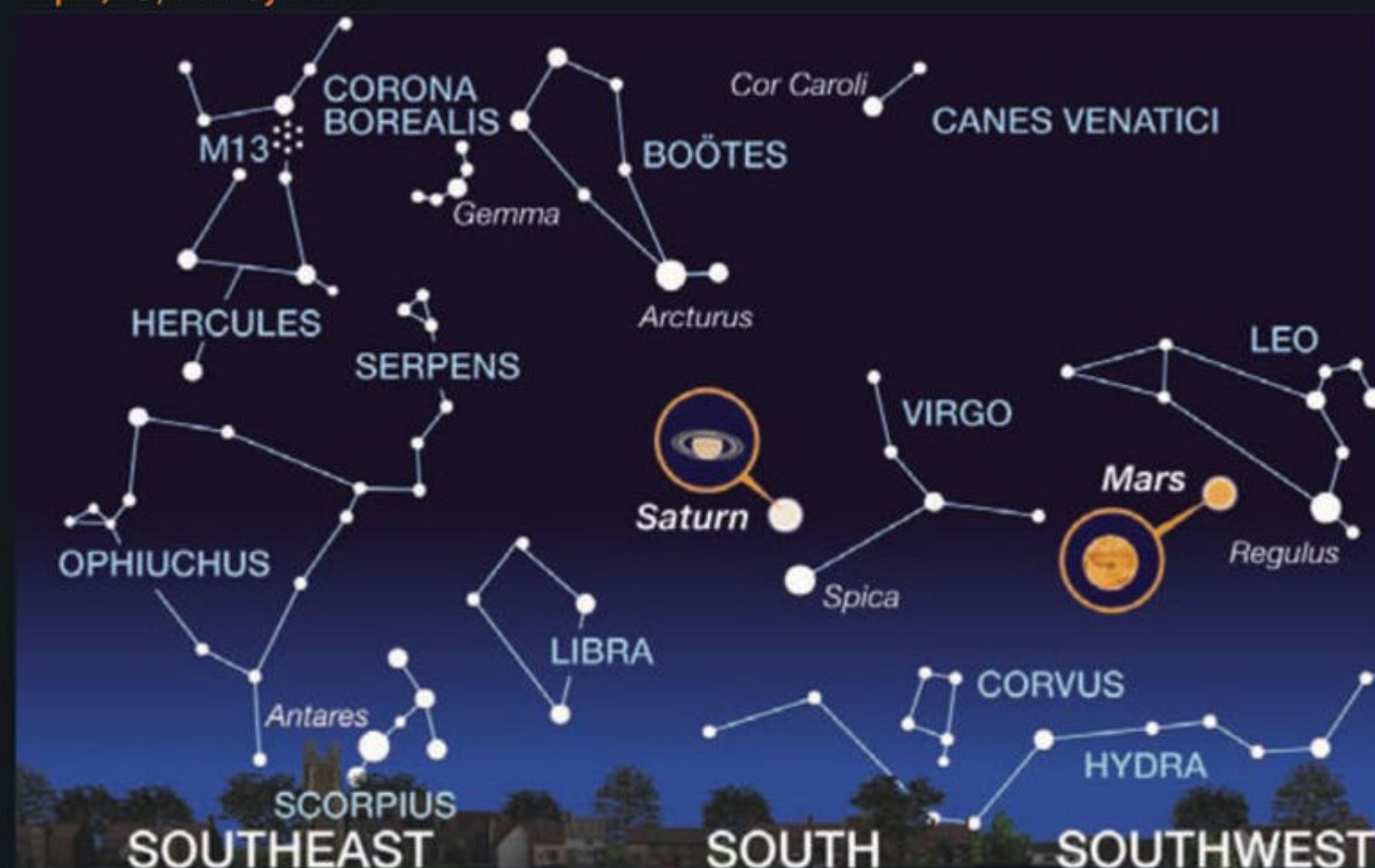
Lots of things – there may be as many as 200 different kinds of headache with different causes. Primary headaches may be caused by tension and overwork. They include migraines, which can last from a few hours up to three days and are often associated with nausea and visual disturbances. Cluster headaches, which come in bouts and are extremely painful, are less common and their cause is unknown. Secondary headaches may be caused by such relatively unimportant problems as tension in the neck muscles, bad posture, dehydration or over-use of painkillers. More seriously, they may be a sign of a brain tumour, a stroke or bleeding between the brain and skull. They may also be caused by carbon monoxide poisoning or by diseases such as meningitis or a variety of eye diseases. **SB**

500,000

An estimated figure for the number of pieces of man-made space junk that are the size of a marble or larger orbiting the planet.

Skywatching with astronomy gurus Heather Couper and Nigel Henbest

12pm, 15/16 May 2012



The large, rambling constellations of May's sky are enlivened by the bright stars Arcturus, Spica, Antares and Regulus, plus the planets Saturn and Mars.

What can I see in May?

● All month, evening, south

Brilliant Arcturus, high in the south, forms the base of Boötes (the Herdsman). The fourth-brightest star in the sky, Arcturus is a pale orange supergiant – not to be confused with nearby yellow Saturn and red Mars.

● All month, late evening, south-southeast

The star-bejewelled 'crown' of Corona Borealis follows Boötes across the sky. It's a small constellation which looks just like its namesake. The celestial crown is rather faint, except for its beautiful, brilliant blue-white central star – called, appropriately enough, 'Gemma'.

● All month, late evening, southeast

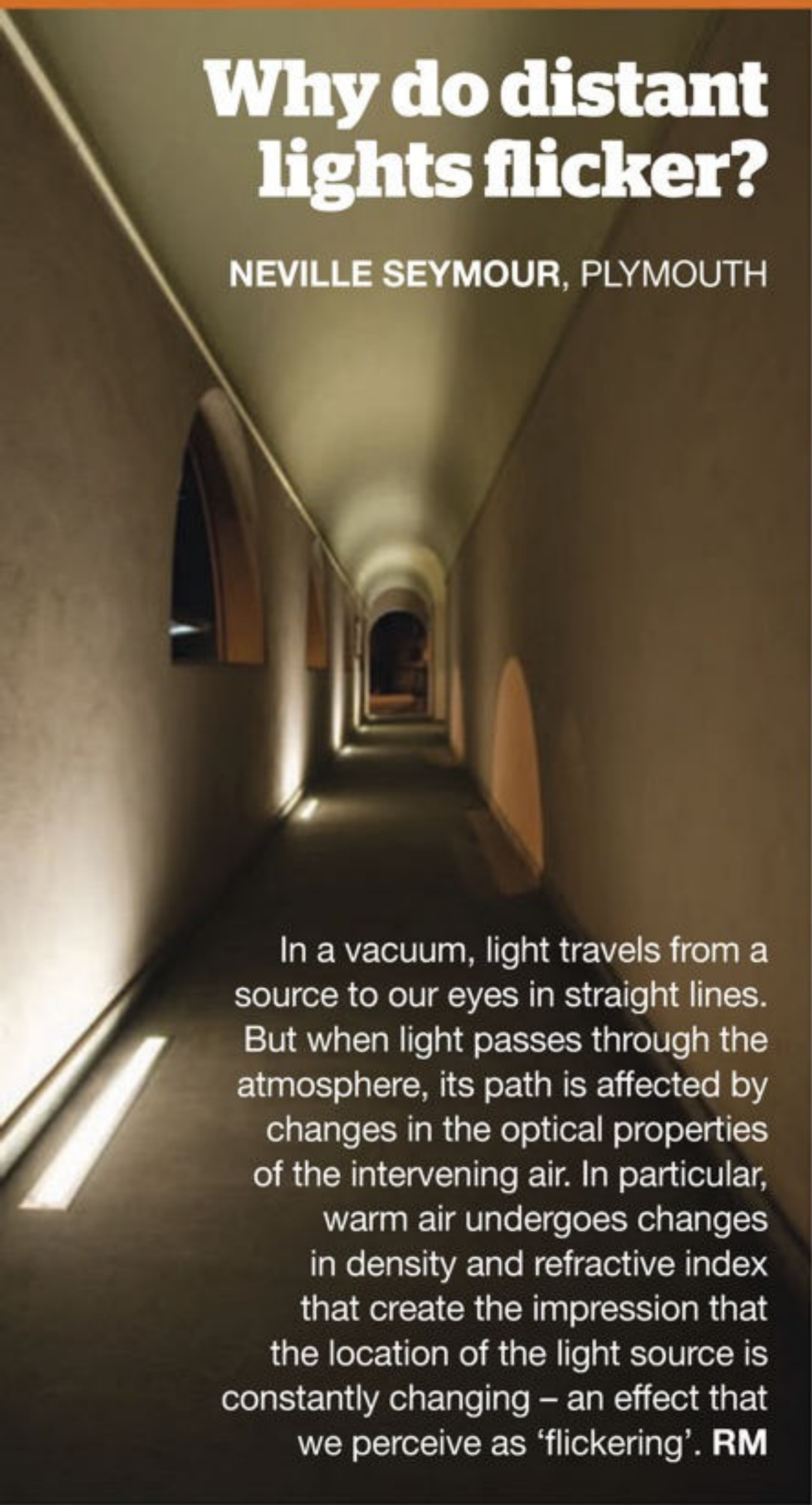
Following Corona is Hercules, another faint star pattern. Look carefully at the right-hand edge of his upper torso and you'll spot a blur. This is the globular cluster M13. It's visible to the unaided eye, but see if you can beg, borrow or steal a telescope to appreciate the true glory of this object.

Watch *The Sky At Night* on BBC One. Check radiotimes.com for details

BBC
one

Why do distant lights flicker?

NEVILLE SEYMOUR, PLYMOUTH



In a vacuum, light travels from a source to our eyes in straight lines. But when light passes through the atmosphere, its path is affected by changes in the optical properties of the intervening air. In particular, warm air undergoes changes in density and refractive index that create the impression that the location of the light source is constantly changing – an effect that we perceive as ‘flickering’. **RM**

What is the future of the internet?

DAN LEE, BY EMAIL



We are heading towards the ‘internet of things’, with everything from your washing machine to the central heating networked. To make these billions of devices identifiable, we are migrating to a new incarnation of the internet protocol (IP). IPv6 is a supercharged version of the existing IPv4, allowing billions of new addresses.

But there are also trends away from global interconnectivity. Iran is creating its own internet, corralling its citizens’ data onto servers within that country alone. Iran is unlikely to be alone for long, as nations and major corporations grapple with threats from activism to cyber-terrorism. At the device level, our refrigerators may well be networked but at the macro level, perhaps the internet will fragment into myriad digital islands. **GM**

Can waves freeze?

REBECCA SADEK, IPAD APP



Even in Antarctic conditions, it just isn’t possible to extract energy fast enough from a solid mass of water to freeze a moving wave in one go. But just as icicles can form from repeated drips, multiple waves breaking on a cold shore can leave a thin crust of ice that gradually builds up into a jagged arrangement of ice shards that resembles a single frozen wave. **LV**

How does an induction hob work?

STEPHEN MOSS, BY EMAIL



Within the hob is a coil of wire through which an alternating current passes. This creates a magnetic field that induces a corresponding current in the metallic base of the cooking pot. For the effect to work properly the saucepan must be made of a ferromagnetic conducting metal. The current induced in the base causes resistive heating. Because the heat is produced in the pot, the hob stays cool, apart from slight heating from the cooking vessel itself. Inductive cooking is more efficient because, unlike gas or traditional electric hobs, only the saucepan is heated rather than the air around it. **GM**

DID YOU KNOW?

The largest human kidney on record was removed from Waziran Malah at Chandka Medical College hospital, Pakistan on 26 January 2010. It measured 30 x 13 x 10cm and weighed 1.8kg, over 10 times the weight of a normal adult kidney.



Is the melting of Antarctic ice boosting sea levels?

SAM HARPER, BY EMAIL

As the biggest expanse of continental ice on the planet, Antarctica would seem the most likely source of increasing sea levels as its ice melts through global warming. In reality, however, current measurements suggest that the amount of ice lost from Antarctica through melting is being roughly matched by the formation of fresh ice. As a result, Antarctica is thought to contribute only around 10 per cent of the sea-level rise attributable to melting ice. **RM**

NEXTMONTH

Is it possible to create a perpetual motion machine?

When will there be a male contraceptive pill?

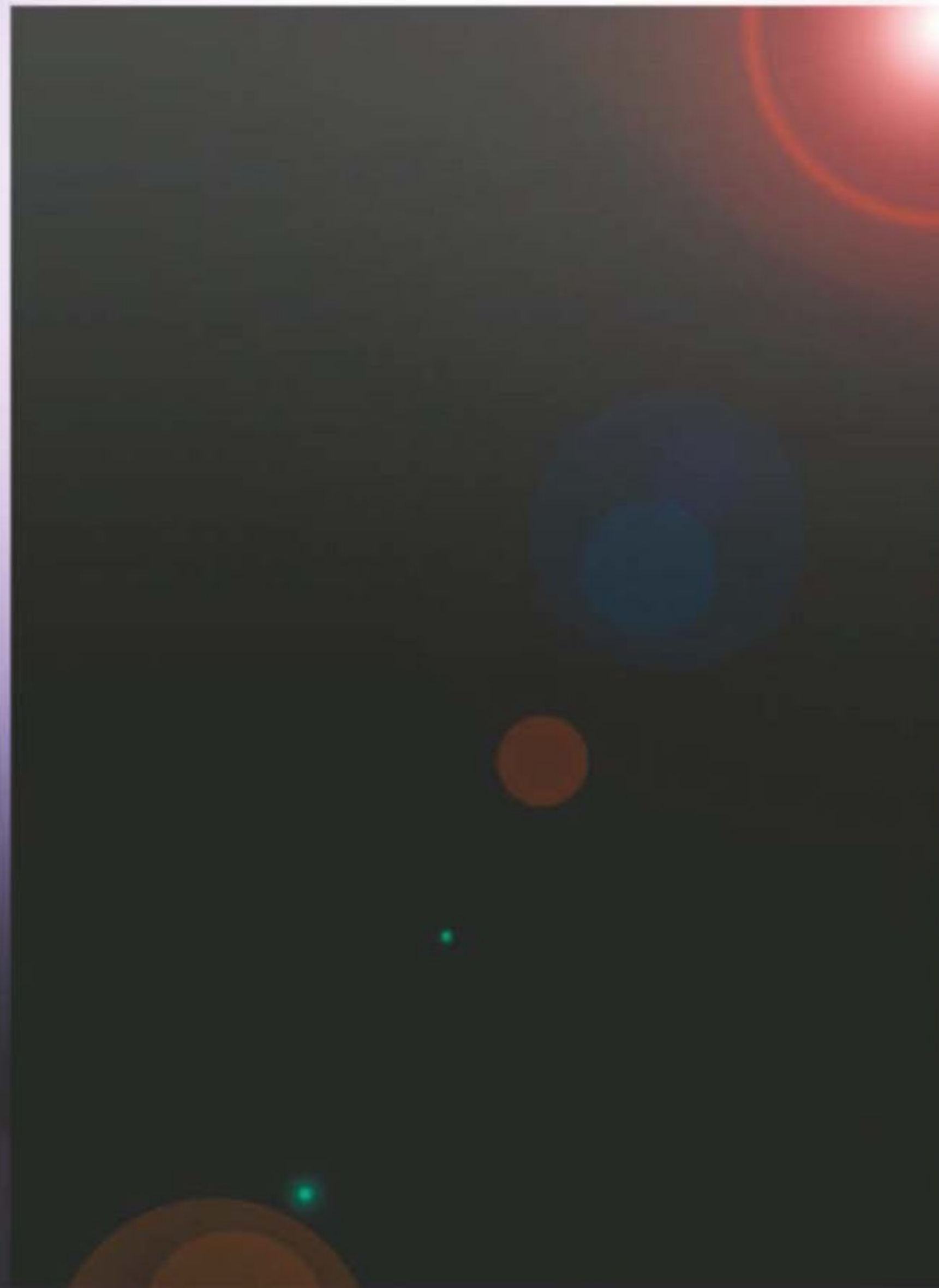
What is the single largest threat to humanity?

Why do your pupils dilate when you look in a mirror?

On sale: 03/05/12

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sciencefocus.com/qanda

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ANIMAL INSIDE OUT

Gunther von Hagens – the man who conducted the first televised autopsy, invented plastination and created *Body Worlds* – is back with a new exhibition

Meet Samba, the Asian elephant (pictured above). This 'plastinated' specimen took von Hagens and his team 64,000 working hours, 40,000 litres of acetone and four tonnes of silicone to make – the total cost amounting to a staggering €3.5 million (£2.9 million). By comparison, the average human body takes a mere 1,500 working hours to complete.

The sheer scale of the exhibit, which includes sharks, giraffes and horses, partly accounts for the long wait for von Hagens' new exhibition. This elephant alone took three years to complete. And even with the plastination finished, there's still the logistical nightmare of securely piecing together an eight-tonne specimen. To manage this, special cranes capable of lifting the dense muscle tissue were called in to move the slices into place, which were then attached to each other with steel rods positioned to mimic the elephant's natural blood vessel system.

As the fruits of all this labour gradually take shape at the Natural History Museum for the show's UK debut, we asked Dr Angelina Whalley – the head curator and von Hagens' wife – which exhibits the team are most proud of. "Samba, and another elephant we've prepared for the exhibition, are the first elephant plastinates worldwide. We've managed to really show, in unprecedented detail, the 40,000 muscles that make up the elephant's trunk."

While all this work is impressive, it begs the question, why plastinate a zoo's worth of animals? "We want to show, with great clarity, the similarities that exist in all vertebrates," she answers, adding, "but at the same time we hope that it'll illustrate the great anatomical variety that has evolved among this group of animals."

Clearly this won't be an exhibit for the squeamish. According to Whalley, after the elephants, the most fascinating displays are the "blood vessel configuration specimens". It sounds like a phrase taken from a horror film, but in these examples the veins, arteries and capillaries of the animals – which include an ostrich and a shark – are injected with a dyed plastic. Once it's set, the surrounding soft tissue is removed mechanically and chemically, leaving only the plastic behind. The result is an animal that, from afar, looks as though it's been painted red. Closer inspection reveals a finely woven mass of blood vessels covering the entire surface of its body. According to Whalley, the result provides a unique perspective: "The arteries can be made visible down to their most minute and intricate clusters of capillaries. The specimens are as beautiful as a piece of art, but give you an idea of how fragile these creatures really are."

Natural History Museum, London,
6 April-16 September, £9/£6, www.nhm.ac.uk

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The Review Squad

Jamie Carter

When he's not writing about high-tech hardware, Jamie's other passion is travel. So he was the perfect person to do a round-up of portable speakers.



Daniel Bennett

Reviews editor Dan is always rushing off somewhere, making him ideally placed to try out the latest lightweight, portable 'ultrabook' PCs.



Bill Oddie

Making his *Focus* debut, the ornithologist, musician and former TV funnyman gives us his opinion of new book *The Great Animal Orchestra*.



Spencer Kelly

This month, the presenter of the BBC's *Click* programme looks at how you can keep your money safe from increasingly devious cybercriminals online.



Jim Al-Khalili

The British theoretical physicist, author and broadcaster reviews new popular science book *How To Teach Relativity To Your Dog* on page 102.





“For people who’d like a home aquarium, but think it’s too much work”

At last, an aquarium for busy people. biOrbs have built-in lighting and simple filtration that really works. The filter cartridges are easy to change and it only takes a few seconds.

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The little 'bot with
big ambitions

This 60cm-tall (2ft) mechanical butler is called NAO and is being used by dozens of universities to develop the world's first robotic assistant for the elderly. As soon as it goes on sale, we hope to have one making the *Focus* tea round.

The dual-core processor powering NAO's brains is loaded with speech and gesture recognition software, so that researchers and developers can teach it to respond to simple commands. NAO isn't just a helpful assistant – it's also a test bed that scientists and programmers are using to develop the first generation of consumer robots. So far it's been used to develop naturalistic walking algorithms for future 'bots, to treat children with autism and to inspire a bigger brother called Romeo that will be better equipped for more strenuous tasks.

Underneath NAO's charming shell is some incredibly sophisticated tech. This new model, the Next Gen, has two HD cameras for eyes that use face recognition software to orient towards, and respond to, humans. It has four microphones for ears that can pinpoint the direction and source of a sound, and a sonar range finder that judges distances. NAO's array of talents has meant that it's now the most widely used humanoid robot in the world and its maker, Aldebaran Robotics, plans to sell a consumer version in the near future.

NAO Robot
Price: TBC
www.aldebaran-robotics.com

Objects of desire

Pixel perfection

Nokia's new phone boasts a camera with a staggering 41 megapixels. This enormous sensor means that you won't really have to compose your photos anymore. Just take a shot, then zoom in and crop the bit of the image you want – the sensor captures so much information that you can get incredibly close to the picture without any pixellation.

Nokia 808 Pure View
Price: TBC
www.nokia.com



Watch your health

Health-monitoring gadgets make us nervous, given that we're no strangers to the odd biscuit, packet of crisps or fizzy drink. That's not to say we can't appreciate a clever gadget. The Basis watch measures your heart rate without a cumbersome chest or arm strap. Plug it into a PC and software will track how many calories you burn, how your heart rate is affected by exercise and your sleep patterns.

Basis Watch
Price: \$199.99 (£125 plus P&P)
mybasis.com



A fine mesh

According to its creators, the lattice design of this bike reduces the frame's weight by half without compromising its strength. The framework of triangles – made from carbon fibre – creates a structure that has a better strength-to-weight ratio than standard tubing. While this all makes sense in theory, we're not sure we'd be brave enough to ride one of these downhill – not after a heavy lunch, anyway.

Delta 7 Arantix
Price: TBC
www.delta7bikes.com

Heavenly tablet

Apple's new iPad boasts a faster processor, better camera and a longer battery life, but the most exciting advance is its new Retina Display. With four times more pixels than its predecessor, the images on the tablet's screen are more lifelike than ever. The improved resolution means that your eyes will find it harder to spot the difference between digital books and magazines and their paper-based counterparts.

iPad
Price: £399 for 16GB model
www.apple.com



Computer candy

Although this may look like just another USB memory stick, it's actually a full-blown Android-powered computer that's about the size of a packet of chewing gum. It plugs into a monitor via an HDMI cable and connects to a mouse and keyboard via Bluetooth. Its 1GHz processor and 1GB of RAM are more than enough to browse the web, use office software and connect to any cloud services you may need to use.

FXI Cotton Candy
Price: £139
www.fxitech.com

Phone filmmaking

Plug an iPhone or pocket-sized camcorder (check with the manufacturer for compatibility) into the Swivl and it becomes a personal cameraman. Put the accompanying microphone/tracking device in your pocket, and the Swivl-mounted camera will follow your movements around the room as it films. Hopefully it'll only be a matter of time before we're all able to host *Blade Runner*-esque videoconferences – well, we can dream can't we?

Swivl
Price: \$179 (£113 plus P&P)
www.swivl.com



Music on the move

Want some tunes on your travels? **Jamie Carter** tests the latest portable speakers



1 Best for... smartphone integration **Jawbone Jambox**

This diminutive speaker box (it measures just 151x57x40mm) can take sound from any Bluetooth-enabled device, be it a PC, laptop, tablet or mobile phone, though there's also an option to hook it up by means of a USB cable or audio jack. As well as pumping out decent sonics, the Jambox's talk buttons allow it to act as a hands-free kit, so you can answer a call mid-tune. Simple to pair with Bluetooth gadgets and with a built-in battery that lasted seven hours in our test, this well-made 347g speaker is ideal for a suitcase, though its soft case is fiddly.

£ Price: £159.99
i www.jawbone.com

2 Best for... kids **iLuv iSP120**

Highly affordable and portable, this 160x100x50mm product from iLuv is a battery-driven portable speaker. On the outside are two well-shielded speakers complete with on/off switch and volume control, while inside is a compartment for three AAA batteries, as well as a cable to attach to whatever smartphone or MP3 player can fit into its interior pouch. Lending some protection to your gadgets, and with a belt loop and clip to attach to a bag or a bike's handlebars, the 200g iSP120 offers only basic audio that doesn't reach high volumes, but it is kid-proof.

£ £14.99
i www.i-luv.com

3 Best for... value **Gear4 StreetParty Size 0**

As slim as a Kindle and just as easy to pack, this 320g dock for an iPhone or iPod Touch – complete with tiny remote control – easily earns its 'Size 0' tag. But there's more to it than portability. Although the mains or four AAA battery-powered unit packs completely flat, a pullout tab wraps around the bottom to produce a prop-stand while also revealing the dock connector for Apple devices. Also including a line-in, the 124x220x16mm Size 0 is at its most useful when playing acoustic music at relatively low volumes – drive it any harder and sound quality starts to suffer.

£ £59.99
i www.gear4.com



What to look for

Connectivity

Some travel speakers connect via Bluetooth to smartphones and MP3 players, while others use docks or cables. Opt for one that suits your source.

Value for money

Unless it's ultimate sound quality you're after, choose carefully – you can often find you're paying big bucks for only a marginal improvement in sound.

Size

A smaller set of speakers might suit your packing needs, but as a rule of thumb the bigger the speaker unit is, the better it's likely to sound.

Build quality

If you're planning to take your speakers away with you, find some which are solidly made and come with strong pouches that also keep cables neat and tidy.

4 Best for... sound quality GenevaSound Model XS

Another Bluetooth speaker, this 157x102x115mm high-grade, Swiss-made option looks like a more retro version of the Jambox, adding an FM radio and alarms. If those are useful on the road, so are its touch-sensitive buttons, line-in socket and a hard carry case that both protects and props up the stereo 2.1 speaker. Pairing it with a smartphone can take a few attempts, and the battery lasts only five hours, but music is refined, well balanced and gets to high volumes without a hint of distortion. Put simply, this 500g blaster is the best all-in-one in the business.

£ £179
www.genevalab.com

5 Best for... portability WOWee One

It's hard to think of a less modest title, but in practice this highly portable speaker offers only a so-so sound. It measures just 26x120x60mm and weighs a puny 200g, charges up via USB and connects to almost anything via a line-in, but its trick of channelling sound vibrations into whatever surface it's left on doesn't always impress as much as you'd like it to. Though it does send slight bass rumbles across the table, treble detailing is slight and the results are harsh at high volume. The best things about the WOWee One are its pocket size and its pocket-money price tag.

£ £37
www.woweeone.com

6 Best for... laptops SoundScience QSB

Hot deskers and those working a lot while away from home will love this simple stereo system. The package comprises two small stereo cubes, each about the size of a mug. A hi-fi quality cable links both together, and another trails to a laptop or PC's USB slot, from where it gets both music and power. At 800g they're bulkier and less versatile than others on test, but these easy-to-install 'proper' speakers come with a tough, red-striped carry case and offer the warmest, widest, loudest and best-defined audio here. They're so good, they could be used permanently on a desktop.

£ £109
www.advancedmp3players.co.uk

Ultrabooks

Need something slim, smart and swift for working on the move? Forget netbooks, the ultrabook is the future. **Daniel Bennett** tests four...

Why would I want one?

Netbooks never quite lived up to their promise. In shedding the pounds to become portable, they seemed to lose most of their brains along the way. Slow and plodding, they are just about powerful enough to check your email or write the occasional Word document. They aren't even that small – and their batteries only last an hour or so before giving up.

But now the slimline figure of the ultrabook is set to change all that. Thanks to Solid State Drives (SSDs) and Intel's latest processors, these high-priced laptops offer most of the power and capabilities of a desktop computer in a machine the size of this magazine.

What's the catch?

These head-turning looks come at a cost. There's no DVD drive for a start. So if you really think you won't get by on downloads alone, then a USB optical drive will be an added cost. SSDs, though fast, are limited in size – 256GB is the biggest you're likely to get – so if this will be your primary computer you might need some added storage. Finally, they're tricky to upgrade. The custom parts and shell needed to achieve wafer-thin proportions mean that if you want to add extra memory or storage later, it's going to be nigh-on impossible.

Why not just buy a tablet?

As far as tablets have come, they're still just devices for consuming content, not creating it. They're great for watching videos, reading and checking your email, but if you want to edit, write or reply, they're just not as useful as an actual laptop with a touchpad and a physical keyboard. These laptops may be double the price of a tablet, but they offer more than double the features.



ASUS ZENBOOK UX31
£1,000

What we tested

Portability

Sure, these are 'ultra-portable' machines, but size isn't everything. A battery that doesn't last will severely limit your ability to get out and about with your ultrabook.

Power

Despite their diminutive size, how many tasks can these machines handle? Power doesn't have to be sacrificed for portability, but it often is.

Desirability

You've got to want to be seen with one... Design is king for the ultrabook and Apple, as ever, has shown others the way until now.

Connectivity

Ultra-slim dimensions needn't mean a lack of connectivity. Can you hook it up to a projector or big-screen TV? Are there enough USB ports for everyday tasks?



MACBOOK AIR
£1,000

LENOVO IDEAPAD U300S
£1,200

ACER ASPIRE S3
£700



MacBook Air

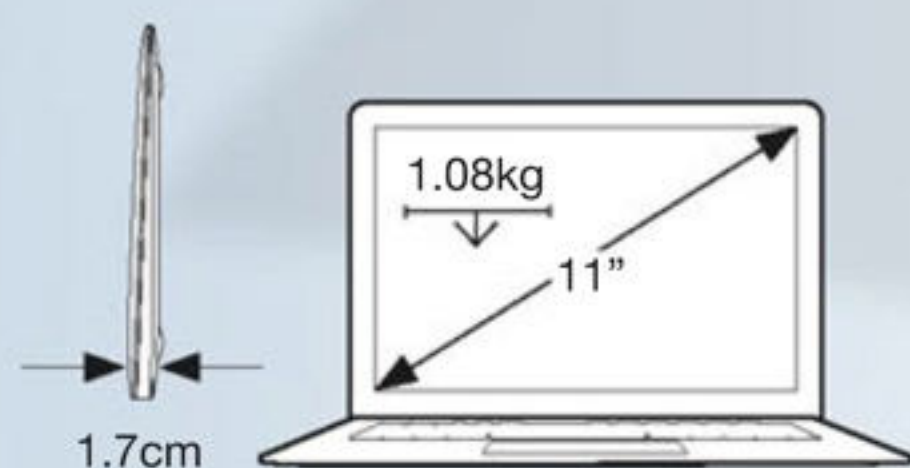
£1,000 www.apple.com/uk

Our review model's 11-inch screen makes this the most portable offering in Apple's MacBook line. Its battery life makes mincemeat of the competition, giving just over six hours of power from a full charge. In just about every department the Air outperforms all-comers. Lightweight movie and photo editing using iMovie and iPhoto is a breeze, but more robust software such as Photoshop (notoriously processor intensive) or Final Cut Pro will make the Air creak somewhat.

Apple's super-quick data connection, Thunderbolt, makes an appearance on new Airs, and if you're prepared to shell out around £800-900 for Apple's 27-inch monitor, the Thunderbolt Display, it will act as a docking station to enhance connectivity

and give you extra USBs, FireWire and an Ethernet port.

The Air's dual USB connections are USB 2.0 only, there's no Ethernet port (although you can buy a USB Ethernet adaptor if that's a real issue) and HDMI is also absent. Macs are never exactly cheap, but the 11-inch (and indeed 13-inch) MacBook Airs are actually pretty reasonable when compared with the other ultrabooks here. And since they're now Apple's entry-level machines, you're not going to find a portable Mac that's cheaper...



Processor: Intel i5; 1.6GHz
Memory: 4GB RAM
Hard drive: 128GB SSD
OS: Mac OS X Lion

Portability: ●●●●●
Power: ●●●●●
Desirability: ●●●●●
Connectivity: ●●●●●
Overall: 17/20

Acer Aspire S3

£700 www.acer.co.uk

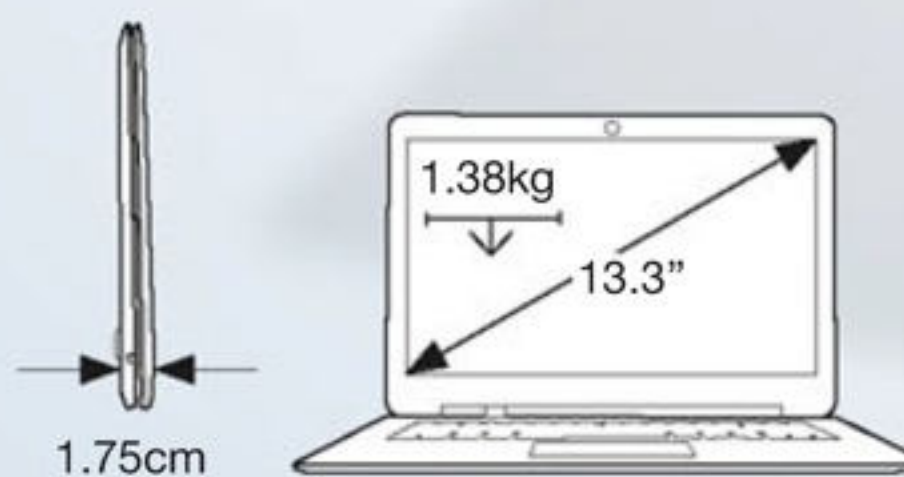
At £700, making it the cheapest model in this test, the 320GB Acer seems like an insanely good deal. And with that sort of storage in a very portable, if fairly bland-looking chassis, that's not far from the truth.

An everyman shade of grey, the Acer isn't likely to set hearts aflutter in the shops. But thanks to the addition of an HDMI port for hooking it up to a TV it will keep many a business type entertained in motorway hotels up and down the country. There are also two USB 2.0 ports to boot and it had one of the nicest keyboards of the group.

Where things fall down is that the 320GB drive isn't an SSD, so it doesn't have the near-instant speed of the other machines here. This means

the whole experience feels slower and in particular, power-hungry software takes longer to load. Acer has cunningly dropped a 20GB SSD cache into the mix that speeds things up, but it's a bit of a fudge and ultimately doesn't pass muster when pitched against the competition.

On top of this, the reflective, 13.3-inch screen makes the Acer almost unusable in bright sunlight, further damaging its claim to be a truly portable device for life on the move.



Portability: ●●●●●
Power: ●●●●●
Desirability: ●●●●●
Connectivity: ●●●●●
Overall: 14/20

Processor: Intel i5; 1.6GHz
Memory: 4GB RAM
Hard drive: 320GB HDD (with 20GB SSD cache)
OS: Windows 7

FOCUS
BEST BUY



Asus Zenbook UX31

£1,000 uk.asus.com

So razor-thin is the Asus that you'll have no qualms about taking it with you almost anywhere. A USB Ethernet adaptor and a VGA adaptor are included, in addition to a micro HDMI port to connect it to projectors, monitors and TV screens, making it a highly versatile machine.

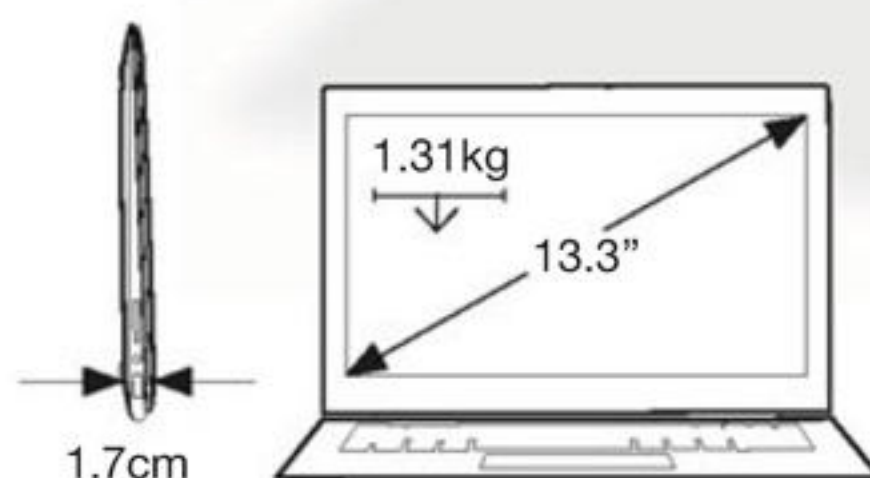
The Asus might be packing a mere 128GB SSD drive, but that's plenty for a little runabout. With a Core i7 chip and a healthy 4GB of RAM, this is a mighty little machine that will handle all but heavyweight photo and video editing.

It can even be taken fairly seriously when it comes to gaming, providing you're not thinking of running a cutting-edge title or playing online. Did we mention the speakers provided by Bang & Olufsen?

For a machine of this size, that is pretty remarkable.

Of the group, the Zenbook is the only laptop on test with looks rivalling the MacBook Air. It does have one blemish, though – a logo plastered somewhat unsubtly just above the top keys of the keyboard.

The Zenbook sports an industry-standard two USB ports, although only one of them is of the high-speed USB 3.0 variety. This ultrabook is £300 more than the Acer, but in this case, more definitely gets you more.



Processor: Intel i7; 1.8GHz
Memory: 4GB RAM
Hard drive: 128GB SSD
OS: Windows 7

Portability: ●●●●●
Power: ●●●●●
Desirability: ●●●●●
Connectivity: ●●●●●
Overall: 17/20

Lenovo Ideapad U300s

£1,200 www.lenovo.com

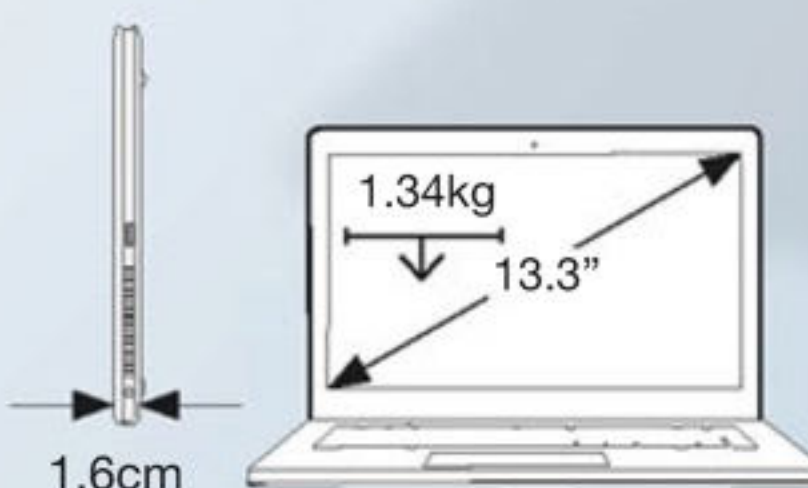
This is a machine that's most definitely aimed at the hard-working salaryman/woman, not the fun-loving, multimedia-munching entertainment market. The matt-coated screen makes pesky reflections a thing of the past, but sadly also makes the Lenovo's display a touch lifeless and drab.

HDMI is included, however, so you can hook it up to a big screen to watch movies. And the 17-second start-up time – quick for Windows – thanks to lightning fast access to the 256GB SSD, made us grin from ear-to-ear. With the same processor as the Zenbook, it can comfortably handle most tasks.

The Lenovo is portable enough, but without a tapered edge it's definitely the biggest of the four. There's no Ethernet port

or adaptor, but it does include two USB ports – one of them 3.0. Battery life is average, at around five hours with heavy use – not quite enough to unseat the MacBook Air or Asus. Its screen is lower-res than both these laptops too.

Sure, it has an SSD with twice the storage of the Asus. But storage is the least of your worries with an ultrabook, given that these days you can buy a 1TB hard drive for less than £70, or just store everything in the cloud.



Portability: ●●●●●
Power: ●●●●●
Desirability: ●●●●●
Connectivity: ●●●●●
Overall: 15/20

Processor: Intel i7; 1.8GHz
Memory: 4GB RAM
Hard drive: 256GB SSD
OS: Windows 7

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With the sheer volume of malware and viruses on the web these days, online banking can feel a little like

taking cash out of an ATM down a dark alley at 1am... while dressed in a tutu. It comes with a sinking feeling that it's not going to end well.

The banks' frontline defence is a small chip and pin device that presents a secure code for 30 seconds after you enter your card. This device is usually sent to anyone using online banking. The secure passwords it generates mean that only someone physically holding your card can access your account. Until recently, it's rendered most accounts



Cyber-criminals keep on finding new ways to rob you

impenetrable. But after a rather alarming investigation with *Click*, I learned that there's a new breed of malware worrying banks, since it bypasses even this level of security.

This crafty bit of code is known as the Man in the Browser. It bores its way into your web browser and lies in wait for you to visit your bank's site. When you arrive at your bank's URL, it springs up a carefully cloned page that, to untrained eyes, looks exactly like your bank's website. Under the guise of a 'training session', it then asks you to key in secure pin numbers generated by the chip and pin calculator, giving the malware full access to your account.

If you've got the most up-to-date antivirus software, you'd hope to be immune to this kind of attack, but our fellow investigators from malware testing lab S21sec revealed that most products won't pick up the malware, as it's new. For now, the only thing standing between you and the Man in the Browser is, well, you. So read our guide on the right to avoid these attacks in future.

Spencer Kelly is the presenter of the BBC's technology show *Click*

How to...

BANK SAFELY ONLINE

Has talk of malware, Trojans and phishing attacks left you feeling dubious about online banking? Then you need the Tech Doc's guide to keeping your money secure...



PROTECT

A new piece of financial malware is always at its most dangerous in the hours or days before the company that makes your security product learns how to spot it and block it. To bolster your defences, use any extra 'secure transmission' software that's offered by your bank, such as Rapport from NatWest and RBS, which locks down your browser and prevents anything tinkering with its communication with the bank.

SPOT

Keep an eye on the design of your bank's site. A complete redesign is usually nothing to be alarmed about, though you should double-check the URL. Malware attacks tend to make more subtle changes that ask for more information than normal – be especially cautious if it asks you to use your chip and PIN calculator. Other signs to watch out for include a transaction taking longer than normal, or failing altogether.

REPORT

UK banks are very good at refunding victims of online fraud, so make sure you report any suspicious transactions as soon as you notice them. A phone call is better than an email, as this can't be further compromised by malware. Your bank will also be watching out for unusual transactions made from your account, so make sure they have your mobile number so they can call you should something not seem right.

Tech Doc's app prescription



MYMUSICCLOUD

All platforms Free

Want to take your music wherever you go, and share it with your iPhone, Android, Blackberry, PC and Mac? That's where MyMusicCloud has one up on many cloud music services. Upload 2GB of tunes free, and they are automatically synced to all your devices – and playable even without an internet connection.



FiLMiC Pro

iOS £2.49

This app helps you shoot more professional-looking video on your iPhone, by giving you full manual control over various settings. You can lock exposure, focus and white balance, and you also get audio metering and variable frame rates. Speaking as a TV presenter, the results are worryingly good!



This reboot of *Syndicate* sees you taking on the megacorps once more...



Syndicate has a strong science-fiction hook: future consumers are in thrall to ruthless corporations

peddling invasive neural chips. But the game only skates along on the surface of this idea. There is definitely an appetite among gamers for smarter sci-fi, but *Syndicate* doesn't quite scratch that itch.

The popular role-playing series *Mass Effect* is a prime example of smart sci-fi, and contains some of the 'hardest' science around. At its core is element zero: a substance with a mysterious field in which the mass of bodies can be altered. Sure, it's an enabling device, but it allows these games to play with ideas about dark energy and exotic future tech, including faster-than-light travel. The 'mass relays' that let you hop around the galaxy have



cores of element zero, manipulating the mass in a channel of space-time between two linked relays.

Great videogame science-fiction doesn't have to be relentlessly technical, though. The splendid *Portal* games don't worry about the workings of the 'portal gun', which fires wormhole-like portals onto walls and floors. Instead, they adopt a light, Douglas Adams-esque touch that embraces and ribs science at the same time.

Gaming's advantage over other forms of entertainment is, as ever, interactivity. In *Mass Effect*, the player is invited to examine the ethics of controlling the population of an aggressive alien race through genetic engineering. By means of multiple choice in dialogue and other options, the game can put questions to the player without stipulating a 'right' answer. And for challenging, thoughtful science-fiction, that's a powerful advantage.

Jane Douglas is section editor of GameSpot UK

ALSO OUT

UNCHARTED: GOLDEN ABYSS



PS Vita
Sony
£44.99

Uncharted makes an impressive outing on Sony's new handheld console, the Vita. Though the dialogue doesn't have quite the same spark as before, *Golden Abyss* replicates the feel of its predecessors' controls admirably and also adds Vita-enabled touch controls; some are effective, others gimmicky. But it's the visuals that really astound here, as the Vita hardware is put through its paces in spectacular fashion. ●●●

TRIPLE TOWN



iOS, Android
Spry Fox
Free

Charming and strategic, *Triple Town* has you build a settlement by placing tiles: three grass tiles become a bush, three bushes a tree, three trees a hut and so on. Bears also roam the grid, blocking item placement until you trap them between tiles. The game is extremely more-ish, so you'll soon burn through your initial free moves, at which point you can wait for them to regenerate or pay £2.49 to unlock infinite moves. ●●●●

PC, PS3, X360
EA, from £34.99

The original 1993 *Syndicate*, a well-regarded game for the PC and Amiga, had you direct a team of cyborg agents in a futuristic global war between different drug manufacturers pushing a mind-controlling opiate of the masses. In contrast, this re-imagining is a first-person shooter in which the warring megacorporations produce digital brain implants, cybernetic enhancements that a large chunk of the population have cheerfully stuck into their skulls.

You play an agent employed by one of these firms to protect its interests – mostly by busting into a rival's base and shooting up the place. That shooting is enlivened by the powers of your own advanced brain chip, with which you can see through walls and hack into an enemy's mind, forcing them to

fight for you or shoot themselves. In addition to the short-ish single-player story, there's also a four-player co-operative campaign to work your way through with friends.

The corporate environments are stylishly rendered, and the shooting is bloody and exciting, if not revolutionary – though the high-tech 'gauss gun' feels like an unfair advantage when shooting homing bullets around corners. The fun flags when you hit some clunky, old-fashioned boss encounters, and it would have been nice to see more inventive chip-enabled hacking powers in addition to the gunplay.

It's tricky to comfort fans who feared a straight-up shooter meant a less cerebral reboot of the original, but *Syndicate* will still keep you entertained. ●●●



Bill Thompson

Will the web be patented?



Sir Tim Berners-Lee, the British scientist who invented the World Wide Web in 1989, is far less wealthy than Facebook founder Mark Zuckerberg. This is at least in part because he never patented his invention. Nor did CERN, the European physics lab where he was working at the time. In fact, in 1993 CERN placed the web's source code and all ideas associated with it in the public domain, so that nobody could claim ownership. As a result, we don't have to pay Sir Tim every time we click on a hyperlink or create a web page.

Many people, including me, believe that this was – and remains – one of the secrets of the web's enormous success. Because it's free of patents and copyright claims, nobody needs to ask permission or get a licence to operate a web server, while web browsers can be produced and given away for free. But while many of the core standards that make the web work are outside the reach of lawyers and those who would like to take a cut from anyone who develops software or builds online services, much of today's web relies on technologies that people think they can lay claim to.

A US company called Eolas has argued for many years that it holds a patent in a way of embedding multimedia in web pages, despite numerous legal setbacks. British Telecom, meanwhile, once argued – unsuccessfully – that it held a patent in the very idea of the hyperlink. The problem wouldn't be as serious if patent offices, especially in the US, were less willing to grant patents on pretty obvious ideas – such as storing customer credit card details for reuse, as with Amazon's patented 'one-click' system.

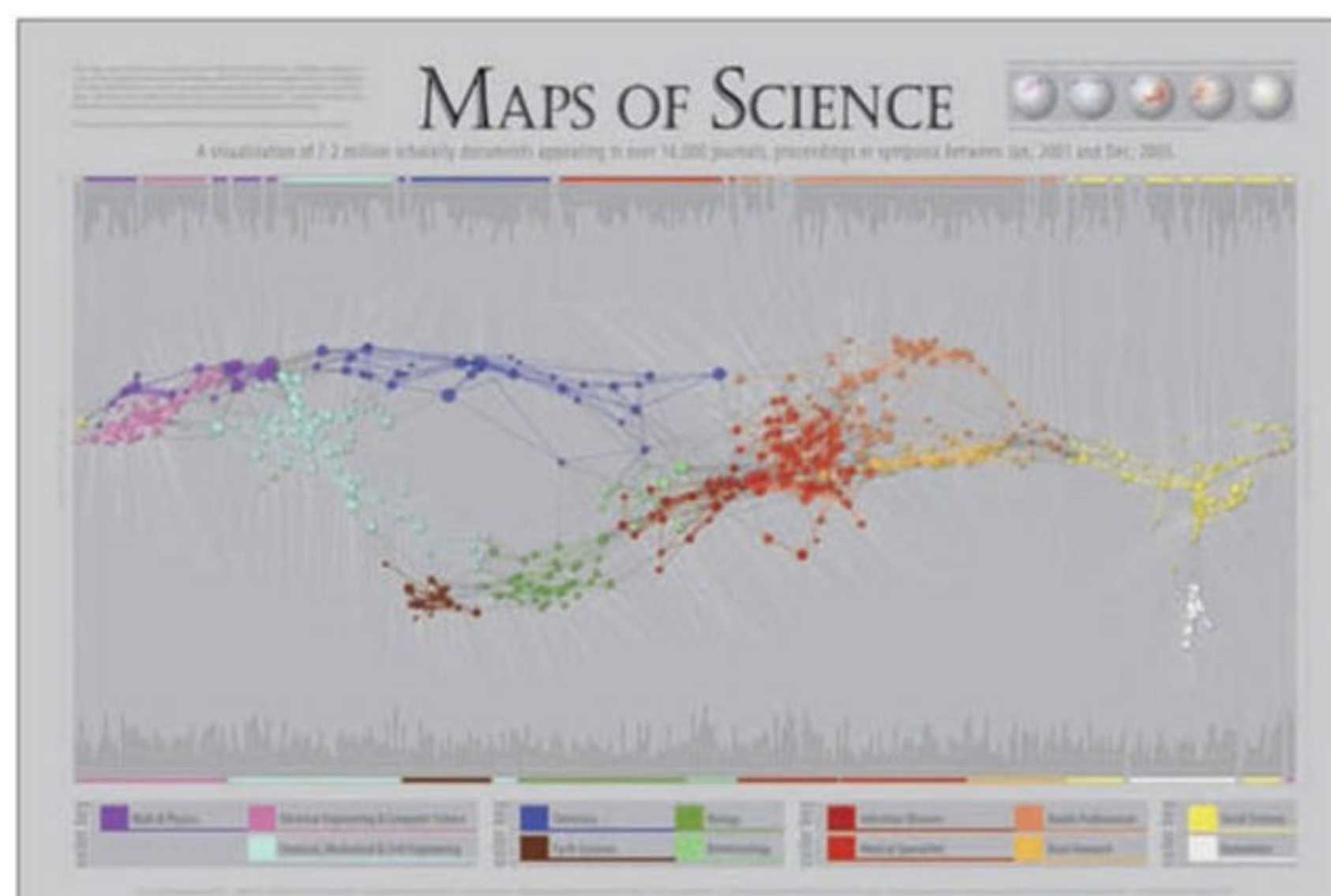
The World Wide Web Consortium, the international body that guides the web's development, will only accept technologies that are either free of patent restrictions or where the patent holder guarantees that they will be made freely available. This is an important principle because it makes the web a common ground, an online space where we are all equal and innovation can flourish.

Yet today, add-ons used by many rich media websites, such as Flash and Silverlight, are proprietary pieces of software with lots of patented ideas embedded in them. The development of the current standard for building web pages, HTML5, has also been fraught with difficulties because companies have been trying to introduce patented technologies into HTML5 specifications. In the end, the web will only stay open if we work to keep it that way.

Bill Thompson contributes to news.bbc.co.uk and the BBC World Service

Places & Spaces

www.scimaps.org



We're accustomed to thinking of maps as geographic, an attempt to represent a territory in a way that allows it to be navigated and better understood. But the term – and the practice of mapping – applies much more widely, as any student drawing a 'mind map' in a lecture can testify.

Places & Spaces: Mapping Science showcases some astonishing attempts to make maps from what we know, rather than the world we live in, visualising things such as the connections between scientific disciplines, research paper citations and even the history of science-fiction (drawn as a squid-like creature). You can browse well over 100 'maps' and zoom in to see details. Each map has a full description so you can see how it was made, and there's also a 'real world' touring exhibition of printed maps and posters. Places & Spaces is an attempt at a cross-disciplinary discussion on how to document scientific progress; these maps do so beautifully.

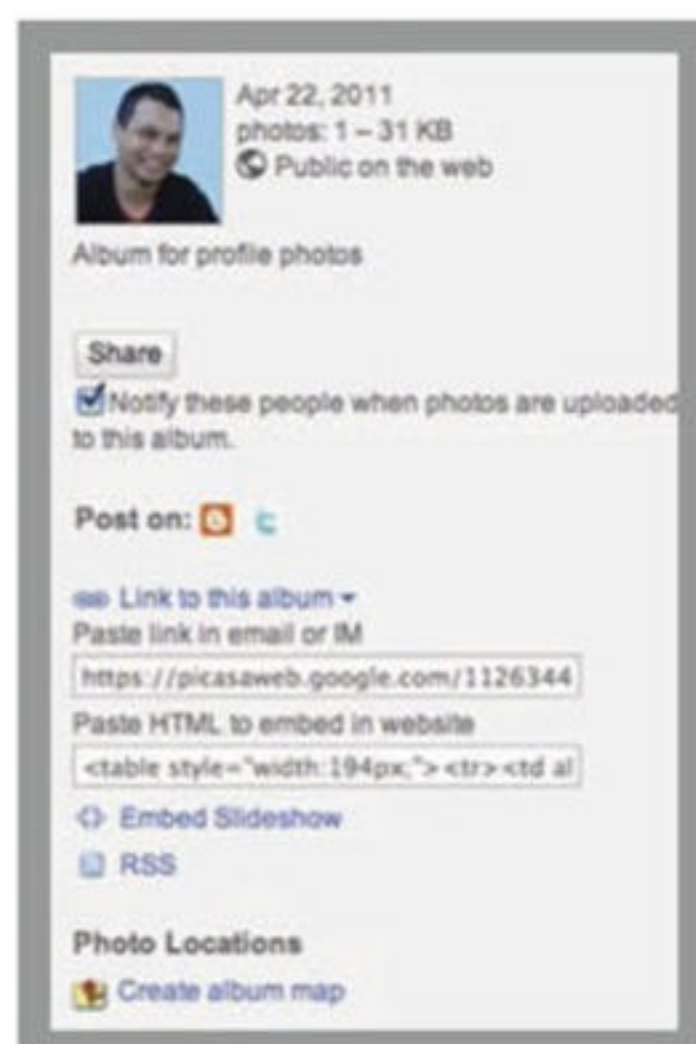
WEB HACKS

How to add a photo slideshow to your website or blog

Step 1 If you use a photo-sharing service like Picasa, it makes sense to embed photos in your personal website or blog rather than re-posting them. To do this, you'll need to copy and paste a small snippet of HTML code. First, go to your photo-sharing service and make a slideshow or create a group of the photos you want, using the tools provided by the service.

Step 2 Copy the HTML code that displays the slideshow. In Picasa, select an album and click 'Link to this album'. In Photobucket, copy the code in the 'Share this album' field. In Flickr, play your slideshow, then click the 'Share' button. Click 'Customize this HTML' if you want to change the slideshow's appearance.

Step 3 Paste the code into the HTML of your website or blog. Remember that you're not adding plain text, so you'll need to insert the code directly. This is usually done by selecting 'HTML mode' in your site editor. In the WordPress Dashboard, for example, this is under 'Appearance>Editor'.



Museum of the History of Science

www.mhs.ox.ac.uk



This lovely website, going back to the early days of the web in 1995, features early scientific instruments from the Museum of the History of Science's wide-ranging collection. As well as 'virtual exhibitions', videos and interactive features, there are animations exploring how the instruments work, some made by children who've visited the real museum. You can also search the database for more information on over 18,000 objects, with detailed photos and catalogue records.

Mind Hacks

www.mindhacks.com



The success of the 2004 book *Mind Hacks* showed just how interested we are in experiments, tips and tricks related to aspects of the brain, such as visual illusions. This entertaining blog offers accessible coverage of research in psychology and neuroscience from the same perspective. It covers topics from the pathology of the Haitian Zombie, via studies of epilepsy, to the early days of the Rolling Stones, and is well worth a visit.

The Great Animal Orchestra

A convincing case that natural sounds make sweet music, says **Bill Oddie**



Finding The Origins Of Music In The World's Wild Places

Bernie Krause

Profile, £12.99

(288pp, hbk)

All but a few creationists must surely accept that music evolved from humans imitating the sounds of nature. Not only bird song, but also the sounds made by other animals, the weather, wind and water. Music was surely inspired by nature, but does that mean all natural sounds are also music?

I once asked sound recordist Chris Watson whether everything makes a noise. "Bill, it's not noise, it's sound," he responded, then added, "Yes, everything in nature makes a sound." When I asked whether he thought those sounds were music, he replied with an equally adamant, "Yes, I do."

Dr Bernie Krause has a lot in common with Watson. They were both chart-nudging musicians: Watson played keyboards for

experimental band Cabaret Voltaire, while Krause has added synthesizers to records by Stevie Wonder and The Doors, and to movie soundtracks as diverse as *Apocalypse Now* and *Rosemary's Baby*. And both are now dedicated to recording wild sounds.

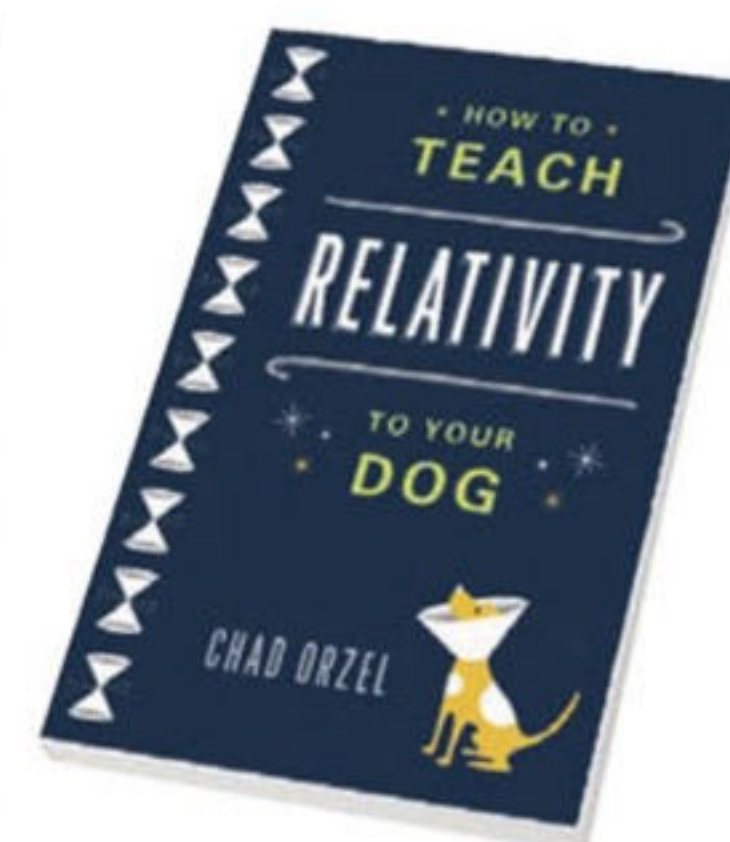
Both also believe that everything produces music, and that the wild has a natural 'orchestra'. A dawn chorus may sound random to us, as songs clash and overlap, but in fact it's governed by rules and routines, frequencies and rhythms that guarantee every creature can be heard. The vocabulary of human music of all eras and styles is present in nature – if you know how to listen for it.

Krause wades into abstruse territory at times (how many of us can decipher spectrograms?) and the lack of an accompanying CD is disappointing. His recordings can, however, be bought online. Titles like *Gorillas In The Mix* indicate a frivolous side – as befits a science book written by a musician.

The ultimate message is that there's an awful lot we don't understand, and even more still to be discovered. There's also a real danger that nature's orchestra is being obliterated by man-made noise pollution. And that is noise, not sound. ●●●●

Bill Oddie is a naturalist and BBC TV presenter

Next time he wakes you up at 6am on Sunday, remember: it's not noise, it's music!



How To Teach Relativity To Your Dog

Chad Orzel

Basic, £11.99

(368pp, pbk)

Our Universe is full of wonder and mystery, and many of us struggle to make sense of it on a daily basis. For many physicists, though, the most amazing thing about the Universe is that, at the most fundamental level, it seems to make sense. The ideas about the nature of space and time that flow from Einstein's theory of relativity are beautiful, logical, even obvious to a trained physicist, which is why many of us were so sceptical when it was suggested neutrinos could travel faster than light.

This book is the latest attempt to explain relativity to a lay audience, by wrapping the science in an amusing and engaging narrative between the author and his dog, Emmy, who addresses the author as "dude". It's informal and has a lightness of touch that can be reassuring when trying to get your head around some big concepts.

So does it work? I found the book entertaining, but the level of the physics is rather too high for a complete novice. Emmy the dog seems to have a solid grounding in calculus, for a start. This puts her ahead of many potential readers, who'll pick up this book hoping the subject has been deconstructed to a level that a less knowledgeable K9 could follow. But then if you really think dogs could understand Einstein, you'll probably need more help than this book provides.

●●●

Prof Jim Al-Khalili is a physicist and BBC TV presenter

Expert Bookshelf

Evolutionary computation

The Power Of Habit
Why We Do What We Do
And How To Change
 Charles Duhigg
 Heinemann, £12.99
 (400pp, pbk)

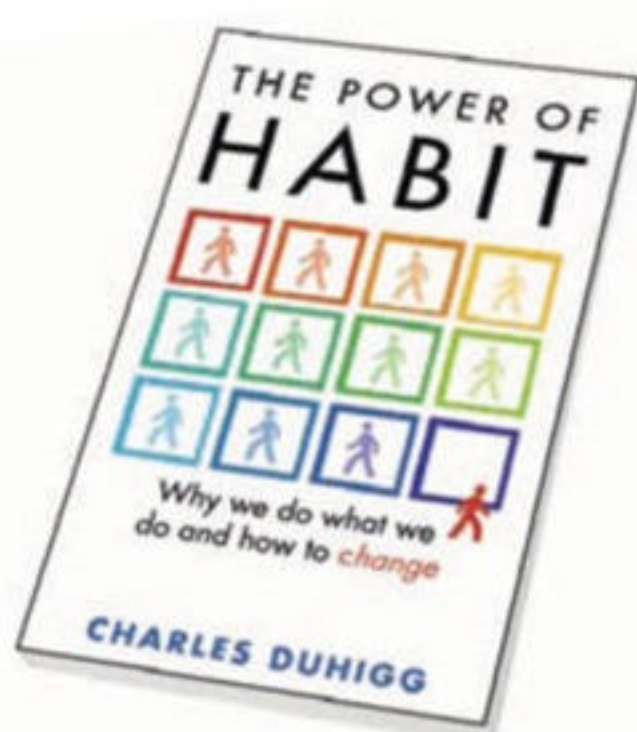
Forty per cent of your daily actions aren't conscious decisions, they're habits. Beneath awareness, cues in the environment can trigger cravings. You respond with automatic routines and the whole habit loop is reinforced with the kick of a reward.

Duhigg, a reporter for *The New York Times*, explains the neuroscience behind this 'habit loop' – the dopamine neurones that fire in anticipation of rewards and drive our mindless routines. The secret to breaking unhealthy habits, Duhigg argues, is to identify the cues, uncover the rewards they make us crave, and then set up healthier routines to satisfy those cravings.

But this isn't a self-help book. Duhigg shows how the habit loop explains the behaviour not just of individuals, but also of organisations and even societies. For example, Starbucks' success was down to the inculcation of customer-focused habits in its baristas, while the US civil rights movement succeeded because it exploited social habits inherent in weak ties and peer pressure.

The central premise does feel rather stretched at times, and some readers may find it light on critical analysis. But there are fascinating, deftly told anecdotes aplenty and Duhigg wraps up with a discussion about what the science of habits means for our understanding of free will. ●●●●

Dr Christian Jarrett is author of
The Rough Guide To Psychology



Chosen by
Peter Bentley



The Blind Watchmaker
 Richard Dawkins (1986)
 Penguin, £9.99

Evolution is capable of producing things that look as though they were made by a craftsman. But you don't need a conscious mind to create such complexity – it can evolve naturally. To illustrate this, Dawkins wrote a computer program that evolved interesting shapes. This was a revelation at the time, and this book was influential for whole fields of computer sciences.



Evolutionary Art And Computers
 Stephen Todd & William Latham (1992)

Academic, available online

Inspired by the Dawkins book above, Latham started using a computer to 'evolve' his artworks, including sculptures that looked like they came from another planet. They're very organic-looking, but they all came out of a computer system he developed with the help of IBM researcher Stephen Todd. This glossy, colourful book explains how they did it.



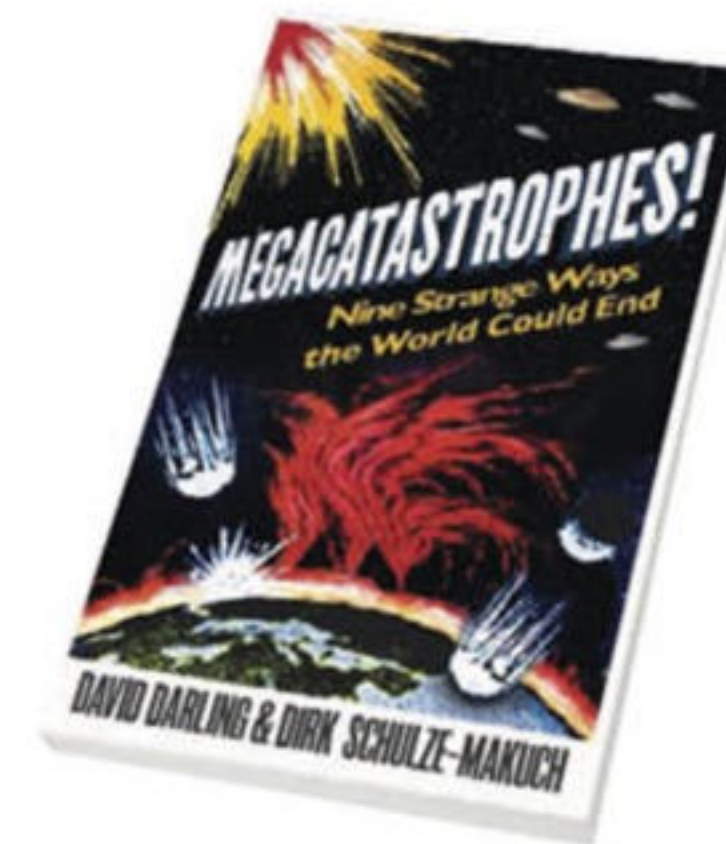
Cambrian Intelligence: The Early History Of The New AI

Rodney Brooks (1999)
 MIT, £22.95

We used to write software for planning, memory and decisions, glue these together and try to control a robot. This is 'top-down' AI. Rod Brooks said AI should be 'bottom-up', using smaller components (like neurones) so intelligence becomes an emergent property. This book changed the way we look at AI – today, we tend to think of it in evolutionary terms.

Dr Peter Bentley is a computer scientist and author of Digitized

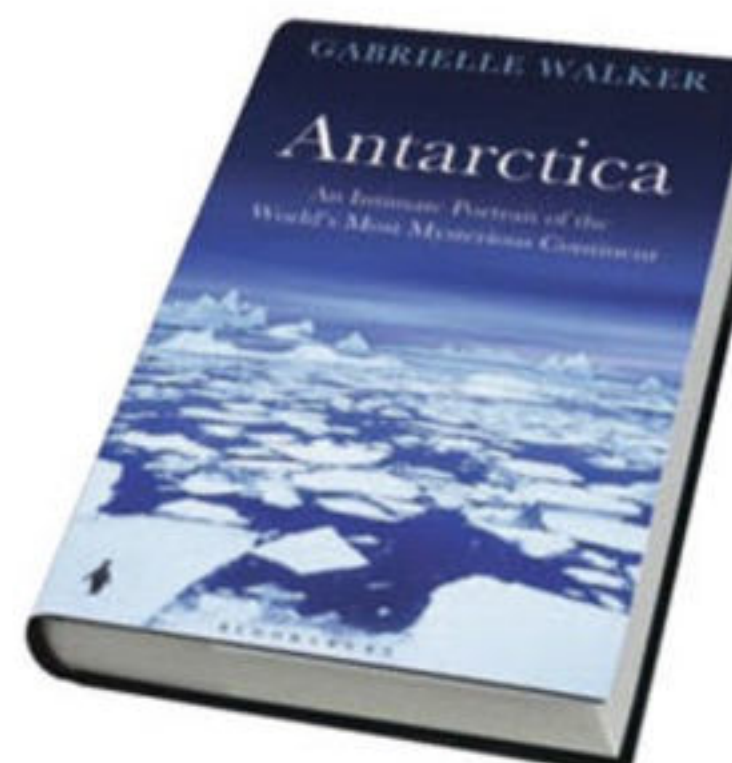
Megacatastrophes!
Nine Strange Ways The World Could End
 David Darling and Dirk Schulze-Makuch
 Oneworld, £10.99
 (256pp, pbk)



If you've been worrying about your five-a-day intake, you don't know what worrying is. Whoever said, "We have nothing to fear but fear itself," clearly hadn't taken pandemics, gamma-ray bursts and 'vacuum meta-stability events' into account. Not even a hi-vis jacket can save you from these cataclysms. A mix of good old-fashioned silliness and some fine lay science writing make this a very readable collection. Next time someone tells you, "Cheer up, it might never happen," throw this book at them. ●●●●

Dallas Campbell presents Bang Goes The Theory on BBC TV

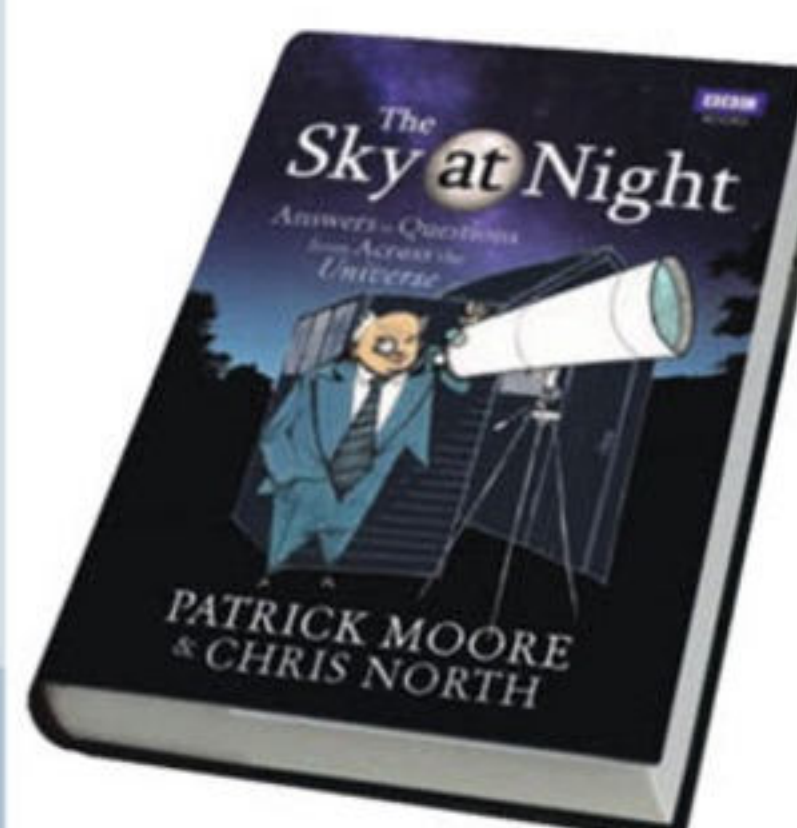
Antarctica
An Intimate Portrait Of The World's Most Mysterious Continent
 Gabrielle Walker
 Bloomsbury, £20
 (416pp, hbk)



Brimful of science, heroism, tragedy and laugh-out-loud humour, *Antarctica* is an exciting and informative read. Eccentric scientists bound from its pages with offerings of Martian rocks, cosmic starbursts and sounds from the Earth's heart. The grim bitterness of an explorer's failure chills your heart, while the joys of human (and penguin) whimsy bring a tear to the eye. Ten years in the making, Walker interweaves personal accounts and in-depth research to tell an intimate, captivating story. ●●●●

Kathryn Jeffs is a producer on BBC TV's Frozen Planet

The Sky At Night
Answers To Questions From Across The Universe
 Patrick Moore and Chris North
 BBC Books, £14.99
 (480pp, hbk)



Covering amateur astronomy, cosmology and space exploration, this book sets out to answer the hundreds of questions sent in to the BBC's *Sky At Night* programme to celebrate its 700th episode. The authors have dealt admirably with both basic and taxing topics, and the personal – and occasionally anecdotal – style of the text gives you a unique insight into their experiences and opinions. If you've ever looked up at the night sky and been struck by a desire to know what's out there, this delightful book is for you. ●●●●

Dr Alastair Gunn is an astronomer at Jodrell Bank Observatory

THE TO-DO LIST

The essential guide to the month ahead

**UNTIL
9
APRIL**



**LAST
CHANCE TO SEE**

**Stephen Hawking:
70th Birthday
Celebration**

As the foremost physicist of our time, Professor Stephen Hawking's 70th birthday is well worth celebrating. To mark Hawking's anniversary, the Science Museum has put together an exhibit exploring his life's work: from handwritten notes on his research to his personal annotations on the script for a guest appearance on *The Simpsons*.

Science Museum, London, until 9 April, 10am-6pm, free, www.sciencemuseum.org.uk

**13
APRIL**

How Should A Chemist Understand Brewing? Beer And Theory Around 1800

As a chemist at the dawn of the 19th century, you could make an extra bob or two advising the brewing industry. In this talk, Dr James Sumner reveals how breaking into the close-knit brewing community was tough – particularly getting hard-nosed industrialists to take instruction from the laboratory and not the counting house.

Royal Society, London, 1-2pm, free, royalsociety.org

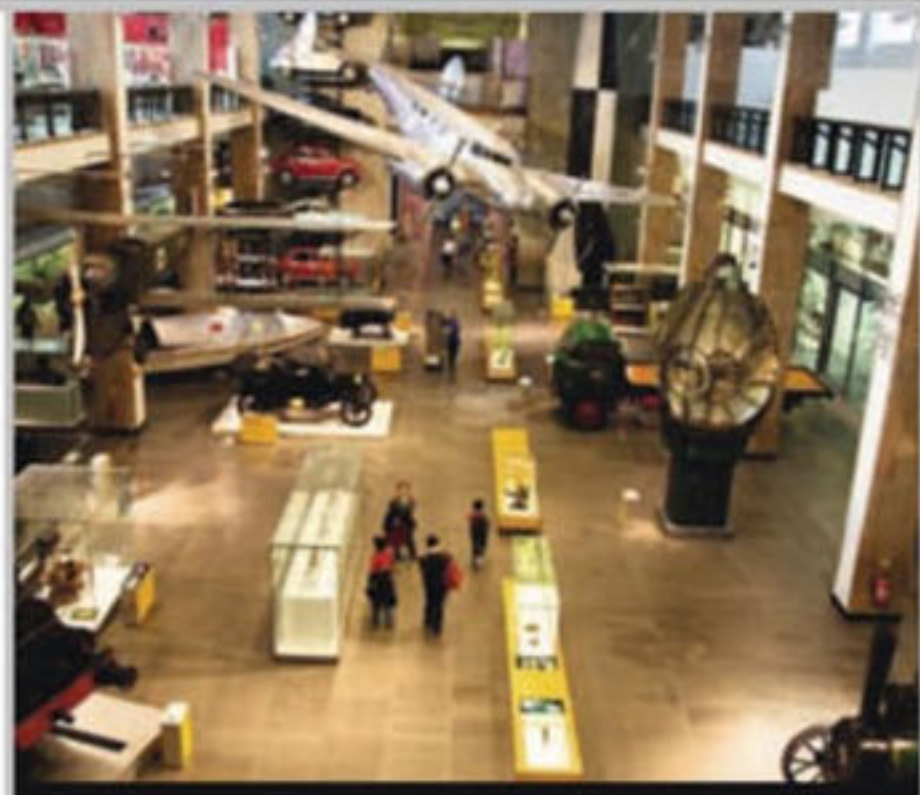
14

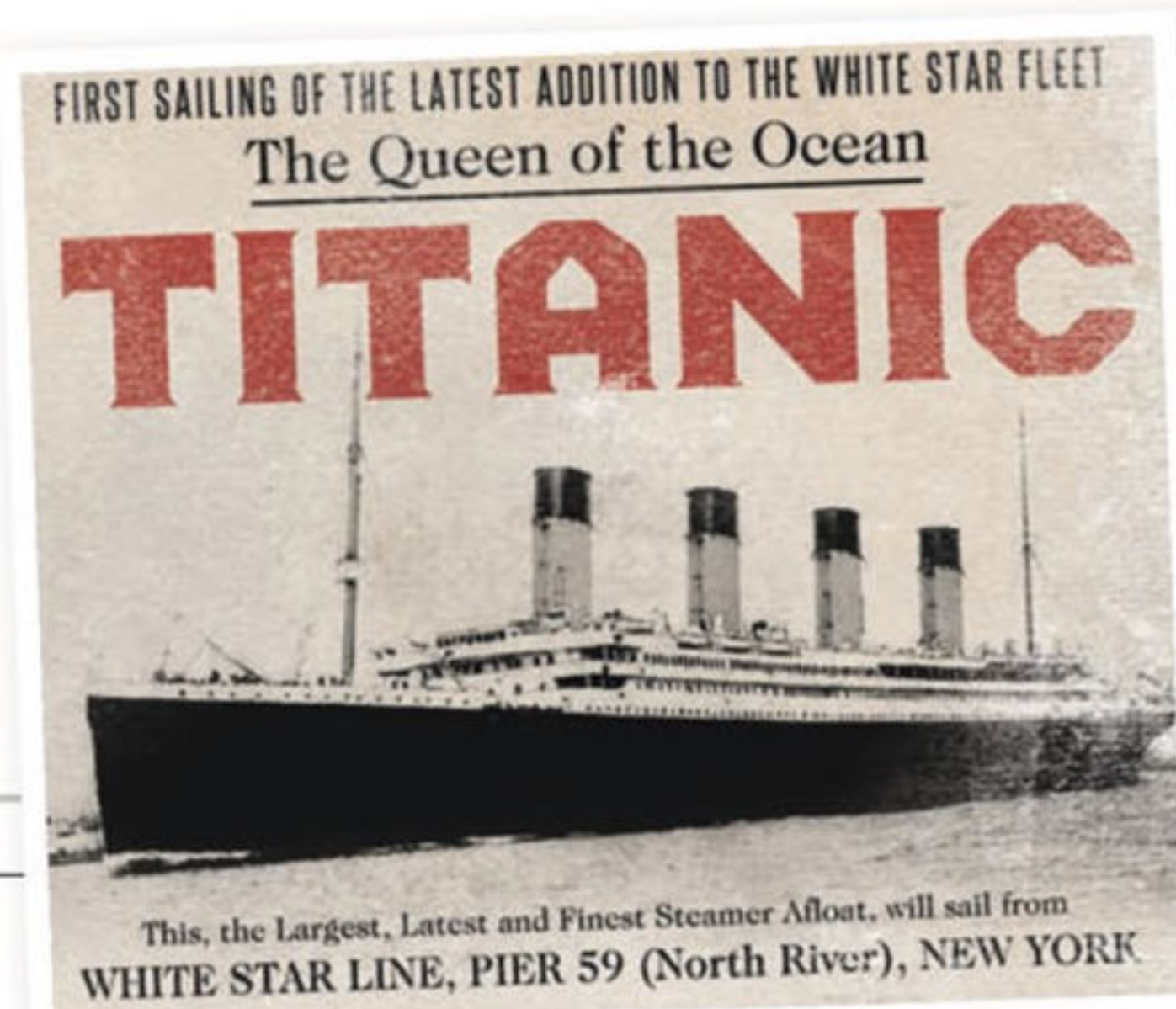
APRIL

Dinner Is Served

One hundred years after the tragic sinking of the Titanic, the food experts at the Centre for Life in Newcastle are recreating the kind of food that first class passengers would have eaten. The meal is accompanied by a talk from the Centre's Head of Education that will run through historic accounts and intriguing anecdotes from the ship, bringing that ill-fated voyage to life.

Centre for Life, Newcastle, £60 (includes five-course dinner and wines), 7pm-midnight, call 0191 243 8216, www.life.org.uk



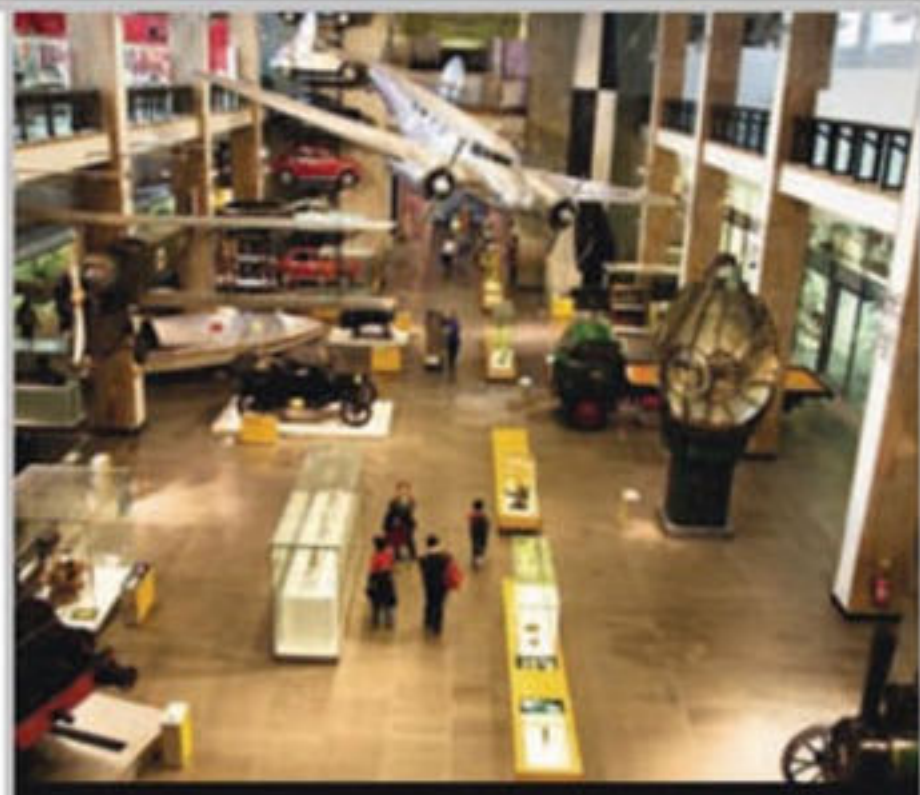


**16
APRIL**

Movement Prints

Take part in this study into the walking characteristics of museum visitors. Find out what your gait reveals about you, and compare it to that of a chimp, or even a T.rex.

Science Museum, London, free, www.sciencemuseum.org.uk

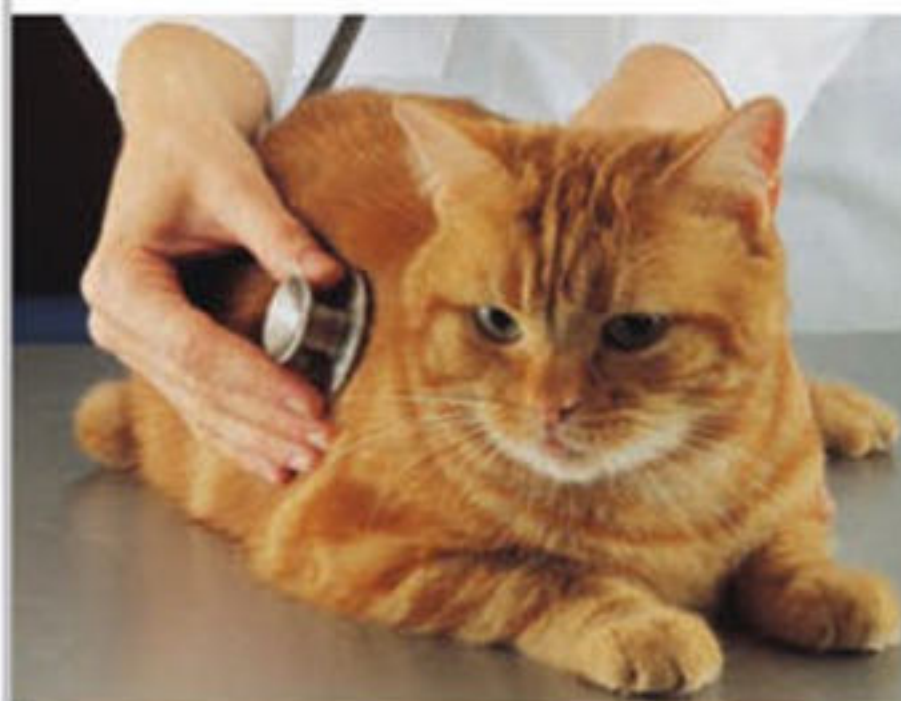


19 APRIL

Mini Vet School

Discover what it takes to be a vet in this six-week course of Thursday night lectures. Experts explain the diverse training that vets undergo, from biochemistry to radiography and from surgery to ethics. Optional practical session on 26 May.

Centre for Life, Newcastle, until 26 May, 7-9pm, £45 (includes practical session), booking essential, call 0191 243 8223, www.life.org.uk



23 APRIL



Dr Andrew Ker

Who is he?

Dr Ker is a computer scientist based at the University of Oxford. His research focuses on hiding information within digital media, or detecting when something has been concealed. This might sound like it belongs in the pages of a spy novel, but embedding information is how digital watermarks are made that verify whether a signal and its owner are authentic.

What's he talking about?

His lecture Hiding In Plain Site delves into the world of steganography – the art of concealing messages so that they are only visible to the sender and receiver. As this is a Café Scientifique event, the audience is strongly encouraged to get involved. You can ask Dr Ker questions about how messages can be hidden without arousing suspicion. Then, over a drink, debate with others the issues around internet security.

Café Scientifique at the Royal Society, London, 6.30-8pm, free, royalsociety.org

**SPEAKER
OF THE
MONTH**

27 APRIL



Happy

What puts a smile on your face? For the easily pleased, a good cat video on YouTube will suffice (there are about 1.8 million of them to choose from). At the other end of the spectrum, adrenalin junkies put themselves in increasingly life-threatening situations just for the thrill of it. The Science Gallery presents the neuroscience and psychology behind what makes each of us happy, whether it's a cute kitten or a sky-dive.

Science Gallery, Dublin, until 1 June, free, www.sciencegallery.com

29 APRIL



Measuring The Universe

The last transit of Venus took place in 2004; the one before that was in 1882. This June, Venus will once again pass across the face of the Sun, as seen from Earth, and then this won't happen again until 2117. In the past, these transits provided an early indication of the vast distances between the planets, giving us the first hints as to the enormity of our Solar System.

To mark the event, the Royal Observatory is hosting a season of talks, events and exhibitions, centred around a gallery that traces science's obsession with quantifying the heavens above. From Halley to Hubble, it'll feature the people and the technology that have explored and measured the cosmos over the centuries. Royal Observatory, Greenwich, until 2 September, free, www.rmg.co.uk

**DON'T
MISS**

1 MAY

Lost In The Andes

The Atacama Desert, a stretch of land sandwiched between the Andes and the Pacific Ocean, is one of the most arid environments on the planet. Discover what it's like working as a botanist here, how species survive in this hostile world, and how two indigenous plants found global fame via the chip and the ketchup bottle.

Natural History Museum, London, 2.30pm, free, www.nhm.ac.uk



TV & RADIO

The month's top science programmes

Inventions That Shook The World



Discovery Science
Starts 24 April, 8pm

Between 1900 and 2000, technology changed human life in ways our great-grandparents couldn't have dreamed of. This 10-part series takes a decade per episode to celebrate some of the most useful inventions – and some of the most annoying.

Yes, the aeroplane and the radio got us off to a fine start, shrinking the world and beginning the century of instant communication. Yes, the Roaring Twenties brought TV and the talkies to entertain the masses. But somebody also had to come up with the small things, like sticky notes, toasters and cat litter, not to mention the parking meter and the Taser.

Behind every one of them is a human story: ingenious engineers solving human problems, or clever business minds looking for the next big thing. Some got rich from their gift to posterity, others had their ideas stolen. You may be surprised to learn the family history of some familiar bits of tech, too. Computer games and the mobile phone have come a long way from their origins, and as for the microwave oven...



Metal: How It Works



BBC Two,
April TBC

Ever wondered why aeroplanes are made of metal, not porcelain? Why a pottery mug shatters when a plastic one bounces, but won't burn your hands the way a tin mug will? Now imagine if there were no metal, ceramics or plastics: the modern world as we know it simply couldn't exist. *Metal* is the first of a three-part series in which Prof Mark Miodownik, who gave the 2009 Royal Institution Christmas Lectures, looks at each of these materials in turn. Not only is his knowledge of materials science broad and deep, his enthusiasm is utterly engaging. Human history is deeply entwined with the history of materials, and Prof Miodownik tells the quirky stories of how we make metal, ceramic and plastics, but how they also made us what we are.



The Gadget Show: World Tour



Channel Five,
April TBC

Back for another series, it's the show that makes gadget-loving geeks get all over-excited and populates a million Christmas lists with the latest shiny technology. But this time there's a twist, as presenters Jason Bradbury and Pollyanna Woodward pack their bags and set off to track down the best kit in the world.

Over 16 episodes, they will check out cameras, consoles and computers from the USA to the UAE. As well as the best the local high streets have to offer, they'll hunt down tech that's still in development. Episode 1 sees them trying to source parts for a robot that can win them a fighting tournament in Tokyo.



Nature: Ice Mountain

BBC Radio 4

20 April, 11am

As we mark the centenary of the Titanic's sinking, this episode of the ongoing nature series takes a look at the other side of the story – the iceberg that tore open the supposedly unsinkable ship. Following an iceberg from its 'birth', calved from a Greenland glacier, the programme intercuts its story with the last few hours of the Titanic. We don't think Céline Dion will be singing, but you never know...

Hurricane Rash

BBC Radio 4

8 May, 11am

The Hurricane may have been a more handy craft in a dogfight than the more glamorous Spitfire during the Second World War, but the location of its fuel tanks meant that a pilot stood a fair chance of being engulfed in flames, even if he landed in one piece. To treat burnt pilots, doctors pioneered new techniques in reconstructive surgery. The skills developed formed the basis for today's cosmetic procedures.

From Easy To Cryptic – 100 Years Of The Crossword

BBC Radio 4

28 April, 8pm

Angry noun mystery is a brain-teaser (9,6). Sudoku and brain-training may be the new kids on the block, but the crossword puzzle, done on paper with a pencil, retains its popularity. Language-loving Lynne Truss goes back through a century of clues and answers, tracking how the puzzles reflect their eras while somehow retaining a timeless, almost universal appeal.



Finding Bigfoot



Discovery
Starts 8 April, 8pm



The Bigfoot Field Research Organisation – team leader Matt Money, Bigfoot obsessive Cliff, ex-roadie Bobo and sceptical scientist Ranae Holland – set off to find the mythical Sasquatch. No, it's not a spoof or a drama series, but we do expect lots of action and excitement as the four go deep into the North American forest and the three guys try to convince Ranae that she should believe.

World's Toughest Expeditions



Discovery
Starts 19 April, 9pm



James Cracknell loves hardship and danger. Thinking up his own hazardous journeys isn't enough for him, so in this four-part series he recreates other people's expeditions, using physiology to analyse the exact hell he's putting his body through. What happened when Dr Livingstone faced the rapids of the Zambezi river, or in the Amazon jungle just before Col Percy Fawcett disappeared? Here's where we just might find out.

Radioactive Wolves



Eden
11 April, 10pm

It's 25 years since the explosion at Chernobyl left the area too contaminated for humans. Since then, wildlife has thrived. Bison, beaver, birds and fish compete for food and breeding space. Studying the top predators gives a snapshot of the whole ecosystem, so scientists are researching the wolf population. Guns and Geiger counters at the ready...



Life On A Wire



Quest
Starts 20 April, 9pm

Nik Wallenda started performing at the tender age of two, and walked his first tightwire aged just four. Later, he even proposed to his wife on a high wire (on bended knee, no less). He's from a famous circus family; Nik's great grandfather fell 120ft to his death. So the performer uses everything science and technology has to offer when planning his spectacular stunts – from engineering to wind speed analysis. Let's hope it's enough.



Sea Of Creepy Monsters



Eden
18 April, 8pm



The depths of Earth's oceans remain largely unexplored – and full of weird-looking wildlife. A film crew spent four years in Lembeh Strait in Indonesia, a spot that puts the 'diverse' into biodiversity. Deadly mini-octopus? Mantis shrimp? An anglerfish swallowing a lionfish? It's all here – in alarming detail, thanks to macro-photography. If you're planning to watch over dinner, we'd suggest you don't have seafood.

Raising Big Blue



Eden
20 April, 8pm



If you've ever been to London's Natural History Museum you've probably walked under the whale skeleton and marvelled at its sheer scale. But did you ever think about how it got there? This documentary follows a team of Canadian scientists, from locating a buried blue whale on Prince Edward Island to reassembling the 85ft skeleton for exhibition in the glass atrium of a museum. Brace yourself for the Missing Flipper Mystery.

BRAINTRAINING

Pit your wits against these brainteasers by **David J Bodycombe**, question-setter for BBC Four's *Only Connect*



Prize Puzzle

When encoded using a 13-letter displacement (A becomes N, B becomes O, C becomes P, etc, and vice versa), the word BOUGHT becomes OBHTUG – which is an anagram of the original word.

Which four-letter insect becomes the reverse of itself (and another valid English word) when similarly encoded?

The first three correct entries drawn from the *Focus* hat will win a Maglite ML100 torch worth £71.99. Visit www.maglite.com to see the full Maglite range. Send your entry, marked 'Prize Puzzle 241', to the address on p109 by 3 May 2012. We regret we cannot accept email entries.

See sciencefocus.com/winners for previous winners and solutions

QUESTION 1

Of all the current holders of the George Cross medal, which one is the largest?

QUESTION 2

Move seven letters up or down one row so that three related words can then be read from left to right:

S RAI P
LCH B EMB
 RO S T R

QUESTION 3

Is it possible to draw a triangle on a piece of paper so that all three of its interior angles are right-angles (90 degrees)?



QUESTION 4

Place +, -, x or ÷ in each box such that X is the lowest number possible. The operations are to be performed in strict left-to-right order.

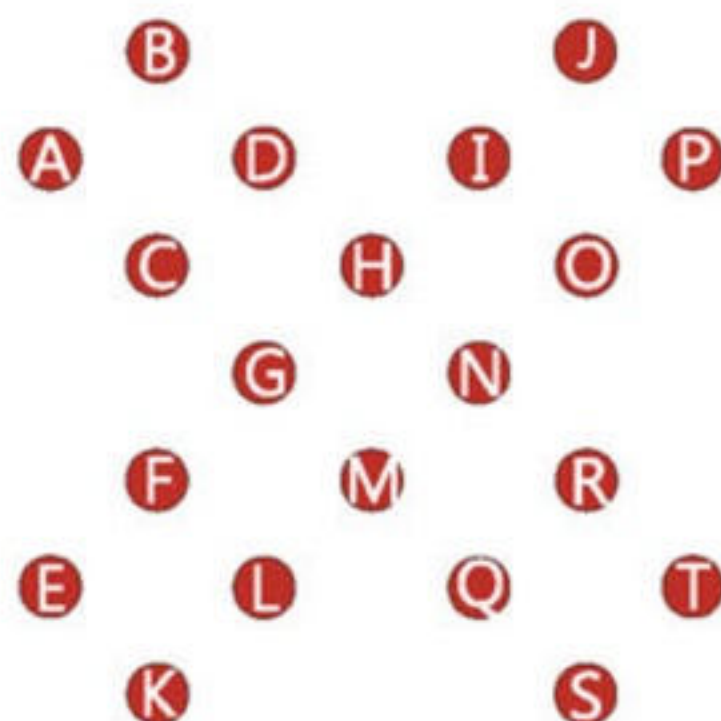
$$9 \square 2 \square 7 \square 4 = X$$

QUESTION 5

What connects the words Baron, billion, Brother, Curium, Connecticut, carat, fathom, foot, hour, Junior, Knight, Mount, Middlesex, near, quart, verb, versus, week and William?

QUESTION 6

How many dots need to be removed so that it is impossible to place the corners of a square on four of them?

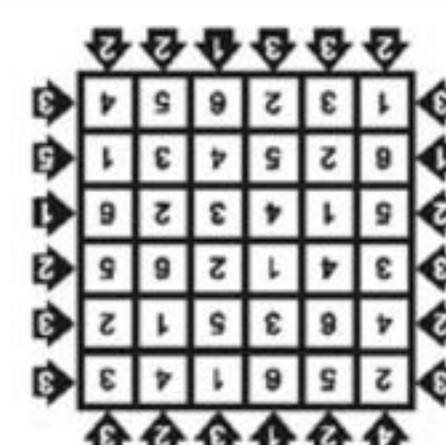
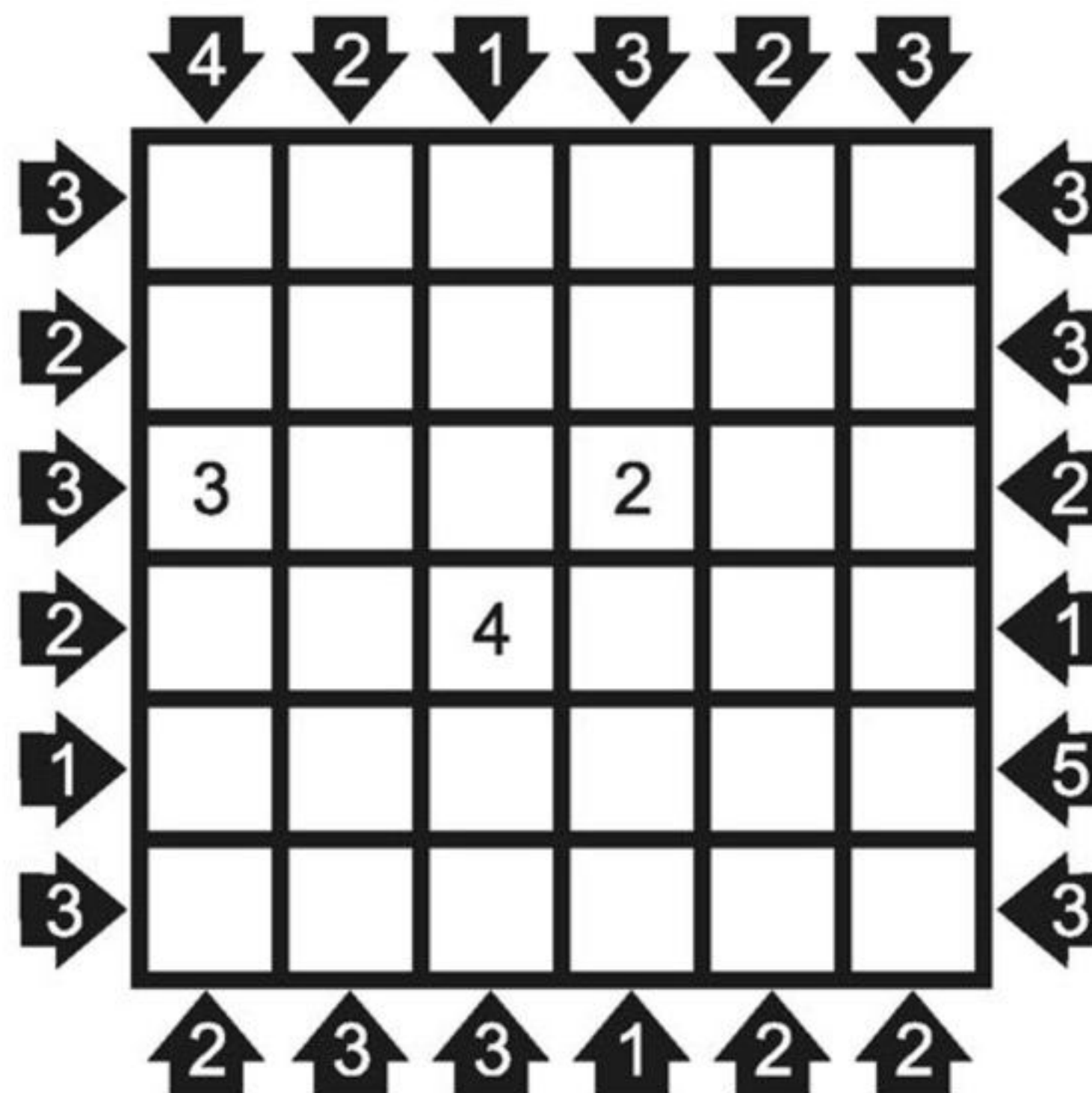


QUESTION 7

Which is larger: 10 to the power of one-fifth, or 4 to the power of one-third?

QUESTION 8

The 6x6 grid represents the 36 blocks of a city plan. Each row and column contains six skyscrapers of different heights (1 to 6 storeys each). Four building heights have already been marked. The arrows show how many of the skyscrapers a viewer, looking from a long distance away, could see in that row or column – with some shorter buildings impossible to see because they are behind taller ones. Complete the grid.



Solutions

Q1) Malta, which was awarded the medal by George VI in 1942. Q2) The words are: shrimp, crab, lobster. Q3) Yes, if the piece of paper is spherical. Eg, on a globe, draw a line down from the North Pole, then along a quarter of the equator, then back up to the North Pole. Q4) The lowest possible result is $9 \div 2 - 7 \times 4 = -10$. Q5) The first and last letters of each word form an abbreviation for the word itself – 'vs' means 'versus', 'Br' means 'baron' and so on. Q6) If six dots are removed (for instance, C, E, F, N, O, T), it is then impossible to place the vertices of a square on any of the remaining dots. Q7) Raising both sides to the 15th power gives 10 cubed versus 4 to the power of 5, which is 1,000 and 1,024 respectively. So, 4 to the power of 1/3 is larger. Q8) See illustration.

Quick Quiz

Test your knowledge of forensic science

QUESTION 1

When was DNA profiling first used to obtain a conviction?

- a) 1976
- b) 1981
- c) 1986

QUESTION 2

What is the scientific name given to the comparison of fingerprints?

- a) Dactyloscopy
- b) Epidermoscopy
- c) Eccrinoscopy

QUESTION 3

Forensic palaeography, also called diplomatics, refers to the examination in a criminal case of what type of material?

- a) Fossils
- b) Documents
- c) Insects



QUESTION 4

Your fingerprints can reveal if you have been using cocaine or marijuana. True or false?

- a) True
- b) False

QUESTION 5

Which of the following is NOT known to have been used as an early form of 'lie detector'?

- a) Soot-covered donkeys' tails
- b) A mouthful of dry rice
- c) A birch stave

QUESTION 6

Rigor mortis – a useful indicator of time of death – usually lasts roughly how long?

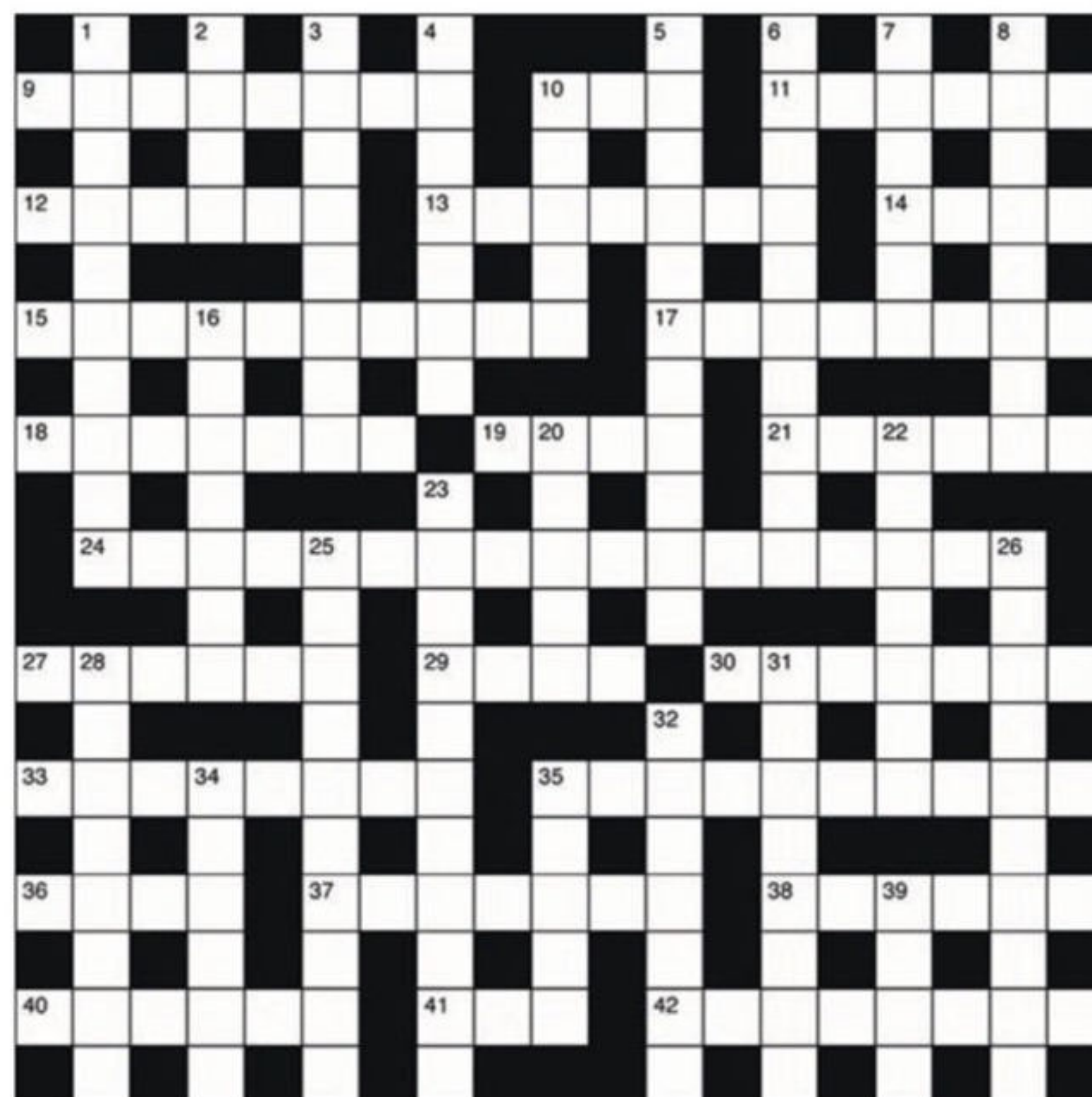
- a) 12 hours
- b) 48 hours
- c) 1 week

YOU ARE:

- 0-2 Inspector Clouseau
- 3-5 Sherlock Holmes
- 6-7 Quincy, M.E.

EVERY MONTH, A NEW CHALLENGE SET BY AGENT STARLING

Focus crossword N°140



Across

- 9 Small harpsichord that's never been played (8)
- 10 The golfer's conceit (3)
- 11 Noble time (6)
- 12 The woman has caught yours truly in plot (6)
- 13 A sign – or cop is mistaken (7)
- 14 Part of the ammunition (4)
- 15 Its theories are both special and general (10)
- 17 Turn tragic, worried about one old tongue (8)
- 18 Figure has right height (7)
- 19 Three feet from Scotland (4)
- 21 Point East (6)
- 24 Organs that take your breath away (11,6)
- 27 Time to put cover round part of shower (6)
- 29 Secret agent shows mutual attraction (4)
- 30 Tolerate part of the alimentary canal (7)
- 33 Novel to take North of ferry port (8)
- 35 Semiconductor sorts train out (10)
- 36 Adheres to report of infernal river (4)
- 37 Battery ideal for arthritic prisoner (3,4)
- 38 CIA and RAF working in many countries (6)
- 40 Something in one's eye after one car crashed (6)
- 41 A great deal of flotsam (3)
- 42 His room changes with pressure, but it's the same shape (8)

Solution to No 137



The first three correctly completed crosswords drawn from the Focus hat will each receive a copy of Planet Dinosaur on DVD. Send your entry, marked 'Crossword 140', to the address below by 3 May 2012.

Congratulations to Alan Smith, Sunbury-on-Thames, who correctly solved February's puzzle and receives a Revell kit of the Apollo Lunar Lander.

YOUR DETAILS

NAME:

ADDRESS:

POSTCODE:

TEL:

EMAIL:

Send your entry to Focus at the address below. Entrants must supply to Immediate Media Company Ltd their full name, postal address and daytime telephone number. Immediate Media Company, publisher of Focus, may contact you with details of our products and services or to undertake research. Please write 'Do Not Contact' if you prefer not to receive such information by post or phone. Please write your email address on your entry if you prefer to receive such information by email.

Send your Prize Puzzle and Crossword entries to:

Focus magazine, Tower House, Fairfax Street, Bristol, BS1 3BN

Down

- 1 Gain city with a weapon (10)
- 2 Indistinct, not starting as a fever (4)
- 3 Riot near erupting at the front (8)
- 4 Public library cat is terribly superficial (7)
- 5 Heard first person behind enclosure find insect part (8,3)
- 6 Room for experiment (10)
- 7 Silver unacceptable to one rodent (6)
- 8 Aid Incas by ordering marine invertebrate (8)
- 10 Affected by one type of wood (5)
- 16 Ordered to train as a craftsman (7)
- 20 Seed of article on bad jokes (5)
- 22 This sum calculated on a strip of land (7)
- 23 Duplicate bike provides circulation of an element (6,5)
- 25 Person is particular (10)
- 26 Crime scoop generated by optical instrument (10)
- 28 Choose fellow who's a bit negative (8)
- 31 He has the will to perform a test on a hill (8)
- 32 Old bait used daily (7)
- 34 Space to terminate husband, returning solvent (6)
- 35 Time to hire a river (5)
- 39 Castle bird (4)



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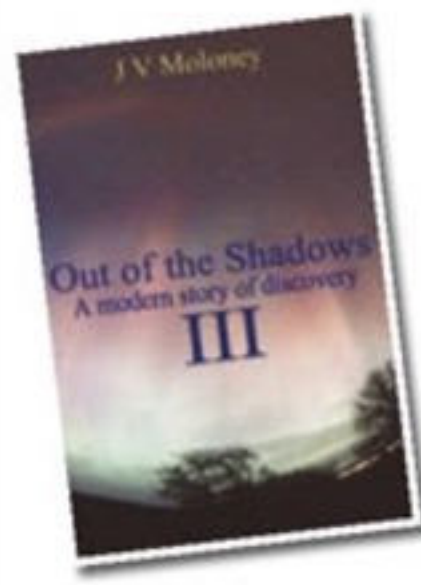
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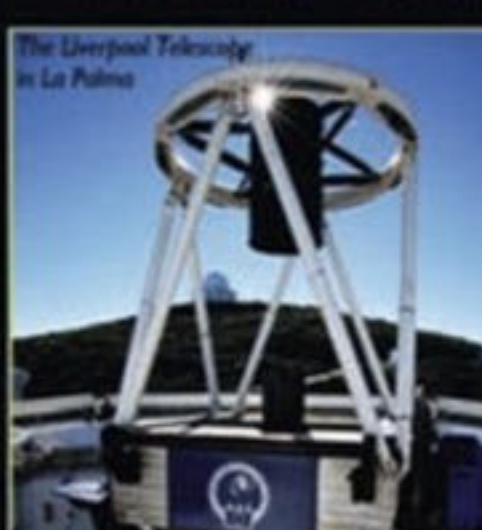


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the ISS**

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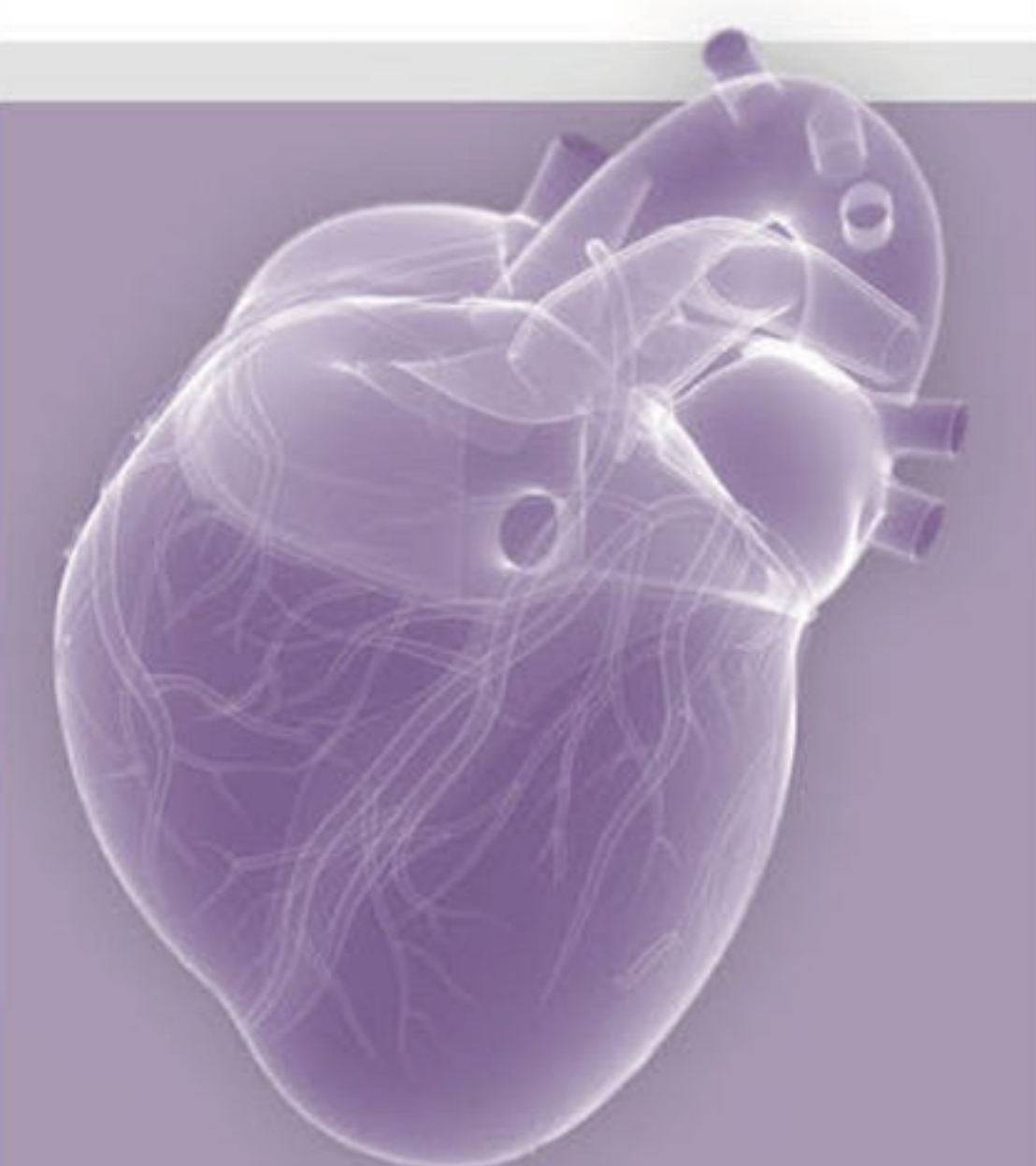
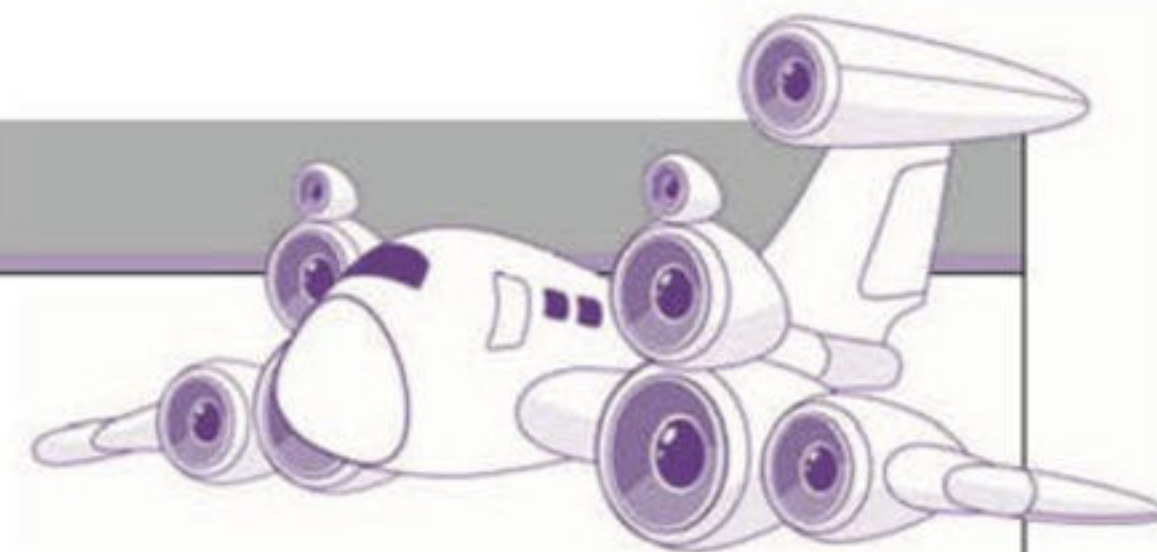
10 per cent
of people are
especially
enticing to
mosquitoes,
**producing
irresistibly scented
sweat that the
insects can detect
from 30m away**

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**A Virgin
spacecraft needs
to reach Mach 3
in order to get into
suborbital space**

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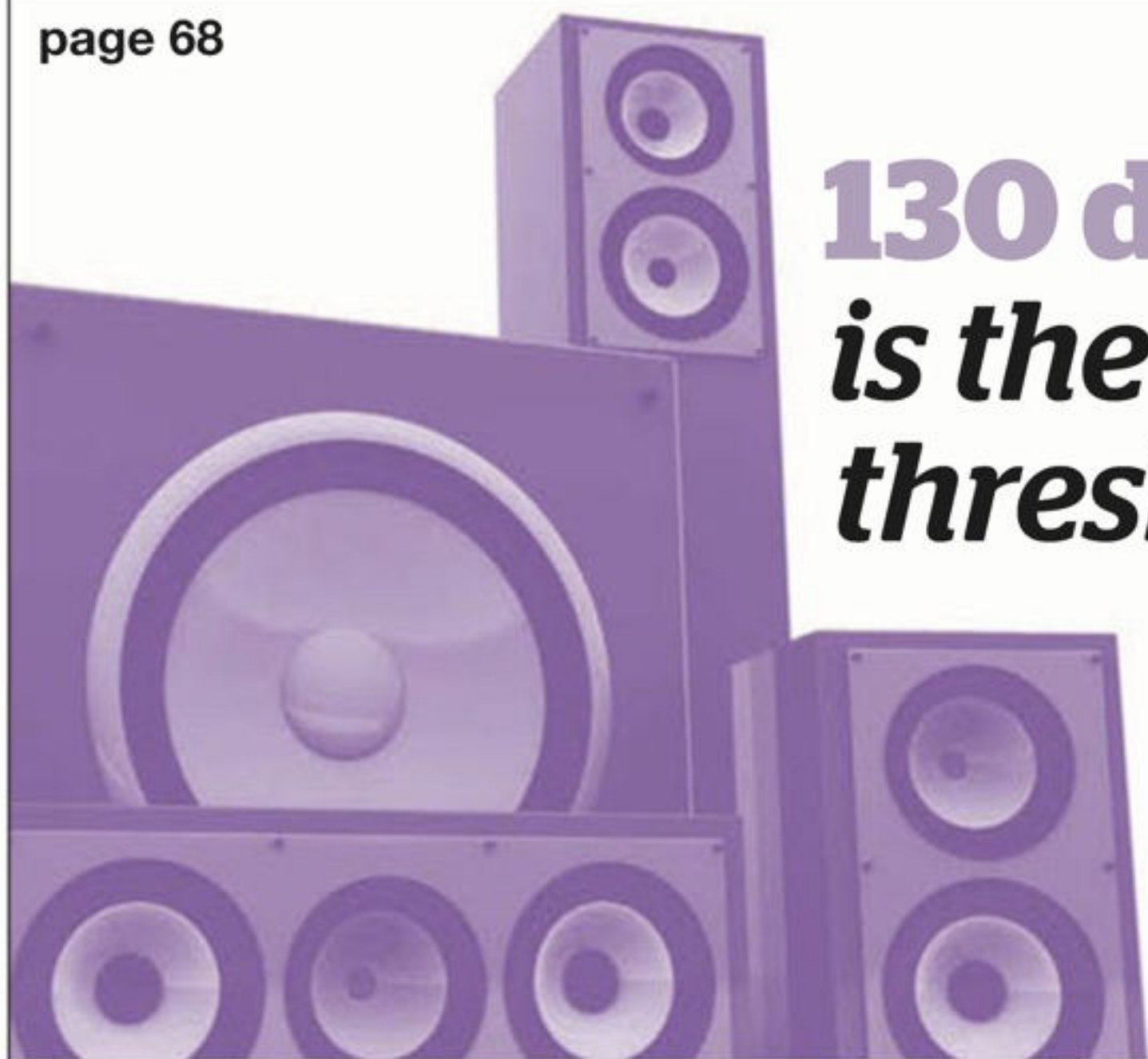


Leonardo da Vinci
made glass models
of the heart to study
turbulence in the blood

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**130 decibels
is the human
threshold of
pain for
sound**



The apparent circling of the
stars around the North Star
is an **illusion caused by
the rotation of the Earth**

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Revival

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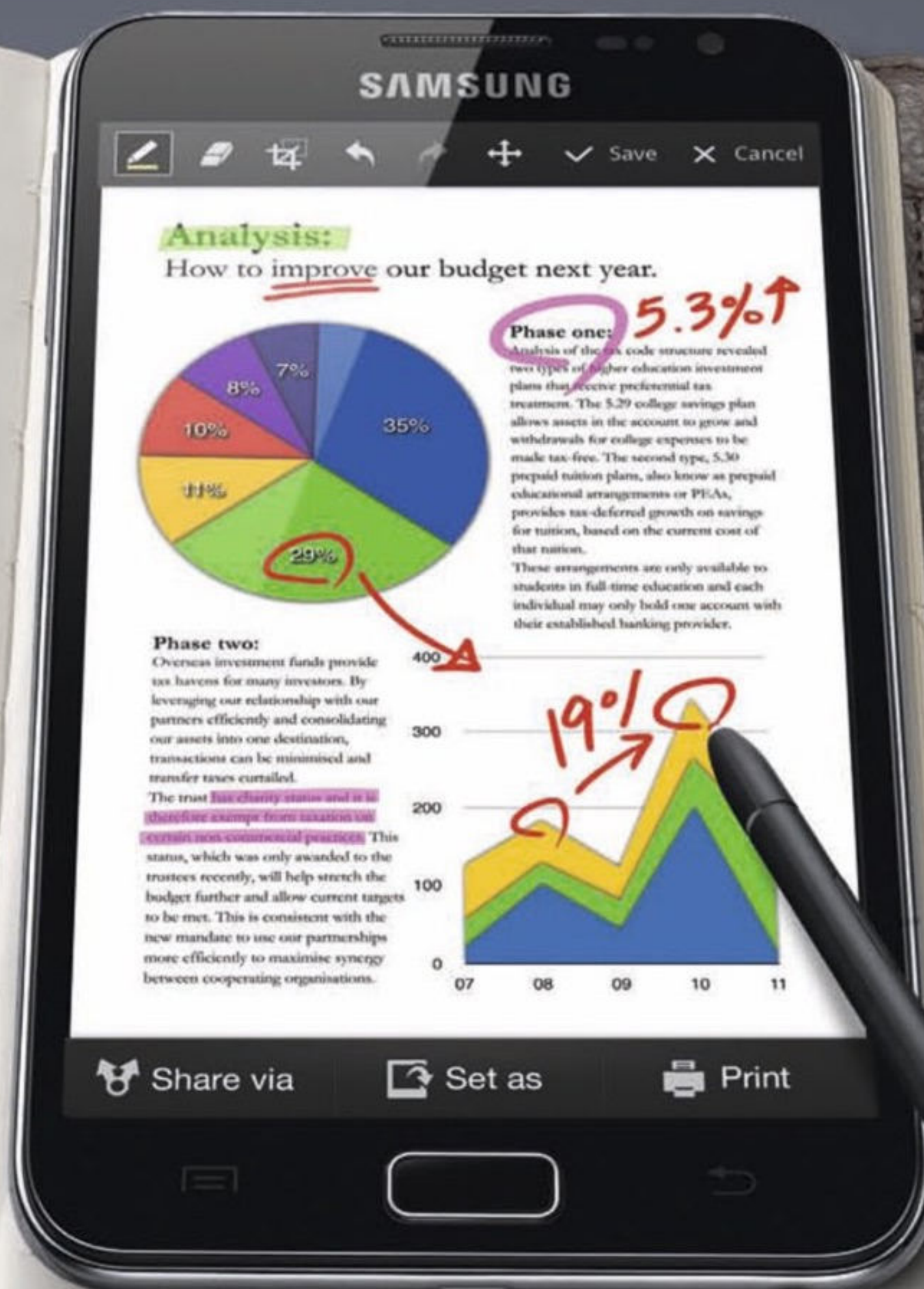


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